Revision of the catch limit for western North Pacific common minke whales calculated in line with the Revised Management Procedure (RMP)

Japan's RMP Team

SUMMARY

After the withdrawal from the International Convention for the Regulation of Whaling (ICRW), Japan resumed commercial whaling for North Pacific sei, Bryde's, and western North Pacific common minke whales in July 2019.

Catch quotas were set by the Fisheries Agency of Japan (FAJ), based on the calculation of catch limits conducted by a domestic specialist's group (Japan's RMP team) in line with the Revised Management Procedure (RMP), with consideration of the reviewing results by an independent group of international scientists (Review Panel).

Regarding the catch limits calculated by the Japan's RMP Team, the Review Panel expressed its concern that 'the value of the NP minke whale catch limit calculated is heavily dependent on abundance estimates for the Okhotsk Sea, with the most recent of these being from a survey carried out in 2003'. Furthermore, the Review Panel noted that 'the catch limit calculation should be updated as soon as the new abundance estimate for this area becomes available, and a revised catch limit should then be set'. Japan has continued the sighting surveys in the Okhotsk Sea in collaboration with scientists from the Russian Federation, and new abundance estimates have been obtained for this area based on sighting data collected from 2015-2020 surveys. Also, Japan has obtained new abundance estimates for coastal waters around Japan and the western North Pacific based on sighting data collected from 2018-2020. The latest estimate of abundance for the single management area defined in the Pacific side of Japan and Okhotsk Sea adjusted with g(0) is 20,961 animals.

An update of the calculations of the catch limit for common minke whales has been made based on the new abundance estimates, updated removals data and some revisions on the *Implementation Simulation Trials* (*IST*) specifications agreed by the International Whaling Commission Scientific Committee (IWC SC) at its 2021 annual meeting. The stock structure hypothesis and definition of management areas are the same as in the previous calculation of catch limit. The acceptable updated catch limit has been calculated as 167.

This document describes the process taken for updating the catch limit of western North Pacific common minke whale in response to the Review Panel recommendation indicated above. First, the new abundance estimates and data on removals are explained in details. Then the calculation of catch limit in line with the RMP is explained together with analyses on uncertainty based on *ISTs*. Japan's implementation of the RMP was and will be based on the best available science, hence, the catch limits will be revised from time to time to reflect the latest scientific information. Other aspects of uncertainty such as a stock structure and MSYR will be duly examined at the full assessment planned tentatively in a six years-period based on the ongoing analyses of new data and samples being obtained from commercial whaling operations.

CONTENTS

1. INTRODUCTION

After withdrawal from the International Convention for the Regulation of Whaling (ICRW), Japan resumed commercial whaling for North Pacific sei whales (*Balaenoptera borealis*), Bryde's whales (*B. edeni brydei*) and western North Pacific common minke whales (*B. acutorostrata*) in July 2019. Catch quotas for each species were set by the Fisheries Agency of Japan (FAJ) for sei, Bryde's and common minke whales within the catch limits of 25, 187 and 171, respectively (FAJ, 2019a, 2019b), which had been calculated by a domestic specialist's group (Japan's RMP team) in line with the International Whaling Commission's (IWC's) Revised Management Procedure (RMP) (JRT, 2019), with consideration of the reviewing results by an independent group of international scientists (Review Panel, 2019). At the review, scientists of the Panel made valuable comments and technical recommendations for improving the works of the Japan's RMP Team in the future (Review Panel, 2019). Among them, the most urgent one was for common minke whales as follows.

'A concern, however, is that the value of the NP minke whale catch limit calculated is heavily dependent on abundance estimates for the Okhotsk Sea, with the most recent of these being from a survey carried out in 2003. A new survey is planned for this area in 2020. The catch limit calculation should be updated as soon as the new abundance estimate for this area becomes available, and a revised catch limit should then be set.' (Review Panel, 2019).

Japan continued the sighting surveys in the Okhotsk Sea in collaboration with scientists from the Russian Federation, and new abundance estimates have been obtained for this area based on sighting data collected from 2015-2020 surveys. Also, Japan has obtained new abundance estimates for coastal waters around Japan (domestic sighting surveys) and the western North Pacific (Japan/IWC's Pacific Ocean Whale and Ecosystem Research (POWER) sighting surveys) based on sighting data collected from 2018-2020.

The objective of this document is to describe the process for updating the catch limit for western North Pacific common minke whales based on the new abundance estimates, in response to the Review Panel recommendation indicated above. First, the new abundance estimates and data on removals are explained in detail. Then, the calculation of catch limit in line with the RMP is explained together with analyses on uncertainty based on *ISTs*.

Japan's implementation of the RMP was and will be based on the best available science, hence the catch limits will be revised from time to time to reflect the latest scientific information. Therefore, Japan will continue to update abundance estimates and investigate other aspects of uncertainties such as a stock structure and MSYR based on the ongoing analyses of new data and samples being obtained from commercial whaling operations. All these aspects will be duly examined at the full assessment planned tentatively in a six years-period.

2. UPDATE OF CATCH LIMIT FOR WESTERN NORTH PACIFIC COMMON MINKE WHALES

2.1 Application for catch limit calculation

2.1.1 Stock structure and definition of management areas

2.1.1.1 Hypotheses on stock structure

The IWC Scientific Committee (SC) agreed on three stock structure hypotheses (A, B and E) in preparation for the *in-depth assessment* of western North Pacific common minke whales (see Figure 1 for the management sub-areas used in the IWC SC assessment):

Hypothesis A: there is a single J stock distributed in sub-areas 1W, 1E, 2C, 5, 6W, 6E, 7CS, 7CN, 10W, 10E, 11 and 12SW, and a single O stock in sub-areas 2C, 2R, 3, 4, 7CS, 7CN, 7WR, 7E, 8, 9, 9N, 10E, 11, 12SW, 12NE and 13.

Hypothesis B: as for hypothesis A, but there is a third stock (Y) that resides in sub-area 1W, 5 and 6W and overlaps with J stock in the southern part of sub-area 6W.

Hypothesis E: there are four stocks, referred to Y, J, P, and O, two of which (Y and J) occur to the west of Japan, and three of which (J, P, and O) are found to the east of Japan and in the Okhotsk Sea. Stock P (earlier termed "purple") is a coastal stock.

During the previous RMP *Implementation*, the IWC SC assigned high plausibility to Hypotheses A and B but it was unable to assign plausibility to Hypothesis E, needing first to await additional genetic and demographic analyses (IWC, 2020a). See further details on the stock structure hypotheses and plausibility in JRT (2019). It should be noted that regarding to Hypotheses B, the occurrence of Y stock has no management implications in the Pacific side of Japan.

For the objective of updating catch limit of common minke whale, Hypothesis A was adopted, the same as in the previous catch limit calculations by Japan (JRT, 2019). Data and genetic samples are being collected from ongoing commercial whaling operations (see section 3) and these will be used in updated genetic analyses in the near future as part of the full assessment. Furthermore, additional genetic markers are being tested and these could be used in the future particularly to assist in the assignation of plausibility of Hypothesis E.

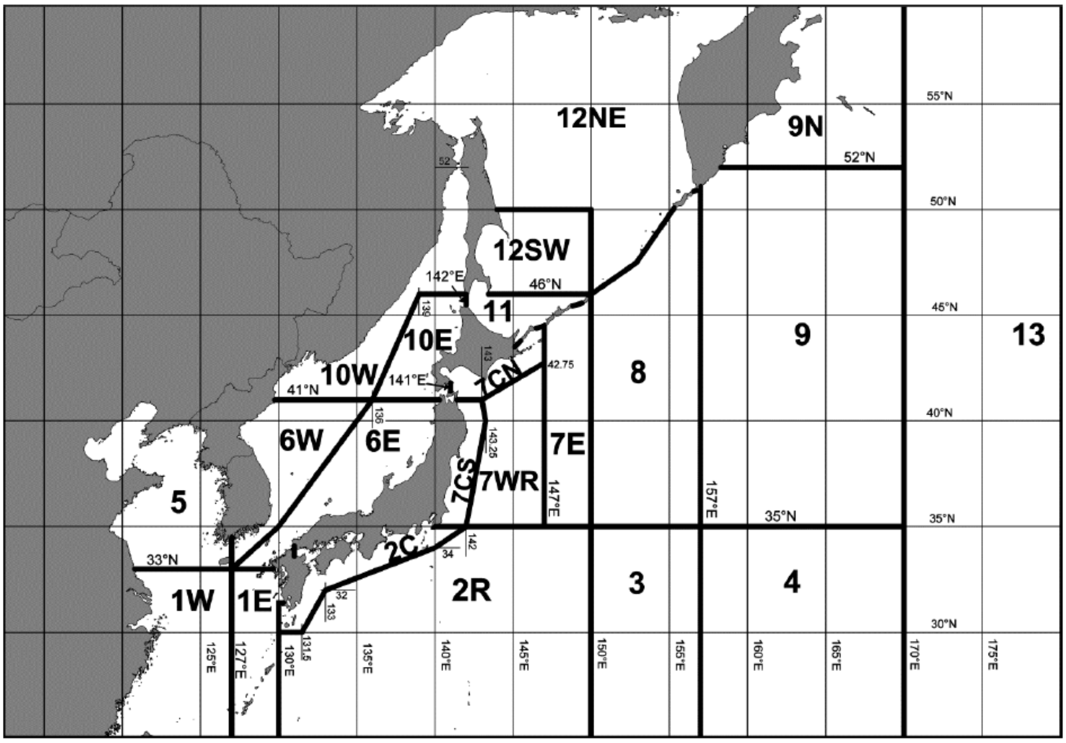

Figure 1. The 22 sub-areas used during the IWC SC *Implementation Reviews* of the western North Pacific common minke whale (IWC, 2014).

2.1.1.2 *Definition of management areas*

The definition of *Small Areas* was not changed from the previous report (JRT, 2019). Four aggregations of sub-areas were considered as follows (Figure 2):

A: sub-areas 7CS and 7CN combined (where mixing of J and O stocks occur)
B: sub-areas 7WR, 7E, 8 and 9 combined (Only O stock is present)
C: sub-area 11 in the southern part of the Okhotsk Sea (where mixing of J and O stocks occur)
D: sub-area 12 in the central and northern part of the Okhotsk Sea (where mixing of J and O stocks occur)

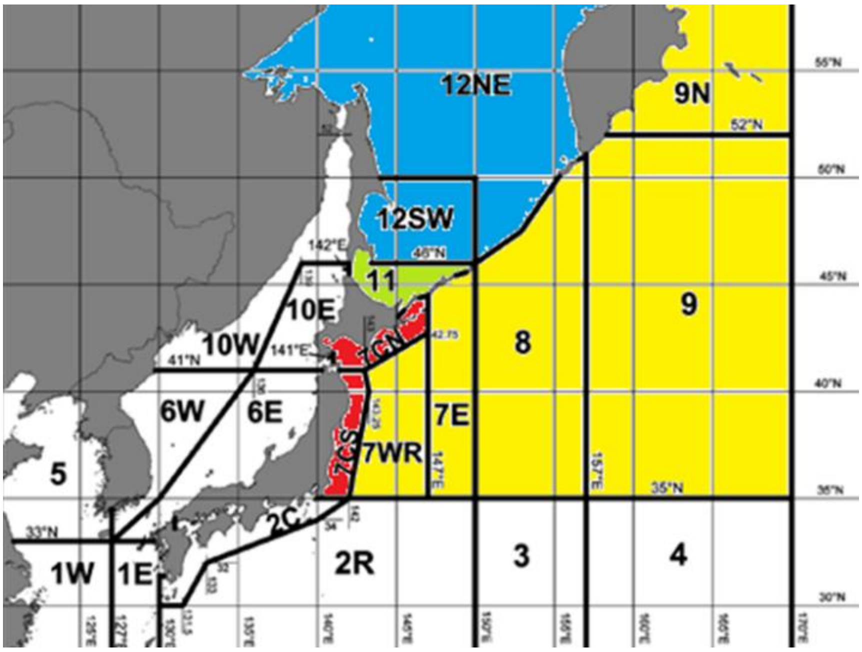

Figure 2. Four aggregations of sub-areas: A (red): 7CS+7CN; B (yellow): 7WR+7E+8+9; C (green): 11; and D (blue): 12SW+12NE.

It was decided to specify A+B+C+D as a *Small Area,* and consequently the abundance estimate and catch history were computed for this *Small Area*.

As same as the previous process (JRT, 2019), different proportions of the O stock whales in the aggregations of sub-areas were considered (Table 1). These options were not changed from the previous calculation (JRT, 2019). All historical catches in this *Small Area* were attributed to the O stock, which constitutes a conservative decision from the perspective of the O stock.

Table 1. Five alternative options (S0-S4) for the proportions of whales present in various aggregations of sub-areas that belong to the O stock.

Aggregated sub-areas	S0	S1	S2	S3	S4
A (7CS, 7CN)	100	80	80	80	80
B (7WR, 7E, 8, 9)	100	100	100	100	100
C (11)	100	80	80	70	60
D (12SW)	100	80	90	70	60
D (12NE)	100	100	100	90	75

2.1.2 Abundance estimates

2.1.2.1 New abundance estimates

Okhotsk Sea

In the Okhotsk Sea, Russia-Japan cooperative sighting surveys had been conducted in summer (August to September) from 2015 to 2020 (Myasnikov *et al*., 2016, Gushcherov *et al*., 2017; 2018; 2019; 2020; 2021). Abundance of common minke whales in sub-area 12NE was estimated based on sighting data obtained during the cooperative Russian-Japan surveys conducted in summer between 2015-2020, under the assumption of g(0)=1. The abundance estimate of common minke whales was used for the revision of catch limit calculation for sustainable commercial whaling of this species in Japan's EEZ, whose process is explained in this document. The annual sighting surveys in sub-area 12NE were conducted by a Russian vessel, the *Vladimir Safonov*, under oversight of the IWC SC. The general sighting methodology is similar to that used by the IWC-POWER sighting survey, which follows the IWC guidelines. The smearing method was applied to reduce the effect on detection model fitting of rounding error in degree estimation. The perpendicular distance was truncated at 0.8 n. miles and multi covariates considered were wind force and visibility. Hazard rate model with visibility was the best fitted model selected by AIC, and the resultant abundance estimates was 15,621 (CV: 0.419, 95% CI: 7,106 – 34,340). Areal coverage was 89% in sub-area 12NE. Year 2018 can be considered as the time stamp based on the weighted mean by research distance. Detailed information on these surveys, analytical methodology, and results of the estimations were described in ANNEX 1.

Coastal Japan and western North Pacific

The Japanese dedicated sighting surveys had been also carried out in spring 2018 and 2019 (May to June) and in summer 2020 (July to September) in coastal and offshore waters around Japan (Matsuoka *et al*., 2019; Katsumata *et al*., 2020; 2021). The IWC-POWER survey was conducted in western North Pacific in summer (July to September) in 2020 (Murase *et al*., 2021). Abundance of common minke whales in coastal and offshore areas in the Pacific side of Japan was estimated based on sighting data obtained during the surveys conducted in 2018-2019 (spring surveys) and 2020 (summer surveys). The abundance estimates were used during the process of updating the catch limit calculations for sustainable commercial whaling of this species in Japan's EEZ. Estimates in the period 2018-2020 were used in the *ISTs* while the estimates in summer seasons were also used for the catch limit calculation of common minke whales based on the RMP's CLA, whose process is explained in this document. The spring and summer surveys were conducted by specialized Japanese research vessels under IWC SC oversight. Abundances were estimated by the standard distance sampling methodology following the guidelines adopted by the IWC SC under the assumption of g(0)=1. In the Sea of Japan, abundance estimates in sub-areas 10E and 6E (assumed J stock animals) were 805 (CV=0.502) in spring 2018 and 2,389 (CV=0.392) in spring 2019. In the southern part of the Okhotsk Sea (sub-area 11), abundance estimate was 306 (CV=0.505) in spring 2018. In the Pacific side, abundance estimates in sub-areas 7CS and 7CN were 103 (CV=0.739) and 159 (CV=0.766), respectively, in spring 2018. Abundance estimate in sub-area 7WR was 77 (CV=1.017) in spring 2019. Abundance estimates in sub-areas 7CN and 9 were 219 (CV=0.671) and 642 (CV=0.703), respectively, in summer 2020. Detailed information on these surveys, analytical methodology, and results of the estimations were described in ANNEX 2.

As noted above, summer estimates for sub-area 12NE, 7CN, and 9 were used for the CLA updating calculations (section 2.1.2.2), and the estimates by month and sub-areas were used for the *ISTs* (section 2.2). Summer estimate for sub-area 11 (306, CV=0.679: estimate from the half-normal model in Miyashita, 2019) endorsed by the IWC SC in 2019 (IWC, 2020b) was also used for CLA calculations. See Table 2 for a summary of the new summer abundance estimates.

Table 2. New summer abundance estimates for North Pacific common minke whale assuming g(0)= 1

Sub Area	Year	Season	Month	Estimate	CV	Reference
12NE	2018	Summer	Aug-Sep	15,621	0.419	ANNEX 1 of this report
11	2014	Summer	Aug	306	0.679	Miyashita (2019), IWC(2020b)
9	2020	Summer	Aug-Sep	642	0.703	ANNEX 2 of this report
7CN	2020	Summer	Aug	219	0.671	ANNEX 2 of this report

2.1.2.2 Abundance estimates for the CLA calculation with g(0) adjustments

As the same as the previous process (JRT, 2019), abundance estimates for the *Small Area* (A+B+C+D) are obtained from the sum over abundance estimates by sub-areas. These estimates were adjusted with g(0)=0.859 with SE=0.103 (for top barrel, IO platform and upper bridge surveys: Okamura *et al*., 2010) for the sum of estimates in sub-areas 7CN and 9 in summer 2020 (ANNEX 2), and g(0)=0.798 with SE=0.134 (for top barrel and upper bridge surveys: Okamura *et al*., 2010) for other remaining estimates (ANNEX 1 and previous estimates). See ANNEXES 1 and 2 for the rationale of this treatment. Table 3 shows resultant abundance estimates for the *Small Area* assuming different proportions of the whales present in that *Small Area* that are from the O stock (see above).

Table 3. Abundance estimates for the O stock common minke whale adjusted with g(0) under several assumptions for the proportion of whales present in *Small Area* (A+B+C+D) which are from that stock.

	A+B+C+D									
	S0		S1		S2		S3		S4	
Year	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
1991*	31,093	0.282	29,152	0.287	29,750	0.286	26,832	0.289	23,784	0.293
2003**	20,513	0.227	19,205	0.226	19,631	0.227	17,792	0.225	15,956	0.223
2018	20,961	0.424	28,833	0.426	20,833	0.426	18,837	0.424	15,863	0.420

*Revised from the previous report (JRT, 2019) through communications with the IWC Secretariat to follow the correction of previous estimates made by the ongoing IWC SC *in-depth assessment* of western North Pacific common minke whales.
**Not changed from the previous report (JRT, 2019).

2.1.3 Catch history and other removals

The historical catch series used for the CLA was updated up to 2020 (Table 4), following the revised *IST specification* made by IWC SC/68C meeting (IWC, 2021).

The series of bycatches (Table 5) was also updated up to 2020 based on the revised *IST specification* made by IWC SC/68C meeting (IWC, 2021), and derived from the *conditioning* run (section 2.2.3). The details of the data used in the *conditioning* are shown in ANNEX 3.

Table 4. Catch history for North Pacific common minke whale for the *Small Area* (A+B+C+D).

Year	A+B+C+D	Year	A+B+C+D	Year	A+B+C+D
1930	13	1960	257	1990	0
1931	14	1961	333	1991	0
1932	22	1962	239	1992	0
1933	23	1963	220	1993	0
1934	32	1964	289	1994	21
1935	33	1965	312	1995	100
1936	24	1966	360	1996	77
1937	58	1967	270	1997	100
1938	68	1968	225	1998	100
1939	72	1969	213	1999	100
1940	79	1970	314	2000	40
1941	60	1971	268	2001	100
1942	71	1972	340	2002	152
1943	102	1973	518	2003	151
1944	79	1974	363	2004	160
1945	69	1975	328	2005	222
1946	99	1976	339	2006	197
1947	125	1977	246	2007	208
1948	169	1978	400	2008	171
1949	134	1979	392	2009	165
1950	202	1980	364	2010	119
1951	233	1981	358	2011	126
1952	293	1982	309	2012	184
1953	234	1983	279	2013	95
1954	275	1984	367	2014	81
1955	374	1985	319	2015	70
1956	456	1986	311	2016	37
1957	357	1987	304	2017	129
1958	516	1988	0	2018	171
1959	281	1989	0	2019	123
				2020	95

Table 5. Incidental catches (bycatches) of western North Pacific common minke whales for A+B+C+D aggregations.

Year	A+B+C+D	Year	A+B+C+D	Year	A+B+C+D
1946	16.0	1971	40.5	1996	38.0
1947	16.5	1972	39.5	1997	37.5
1948	17.5	1973	38.0	1998	38.5
1949	18.5	1974	37.0	1999	39.5
1950	20.0	1975	36.0	2000	39.0
1951	22.0	1976	35.5	2001	39.5
1952	22.5	1977	35.0	2002	42.5
1953	24.0	1978	34.0	2003	43.0
1954	25.0	1979	41.0	2004	40.5
1955	26.5	1980	41.0	2005	38.0
1956	27.0	1981	40.0	2006	39.5
1957	28.0	1982	39.0	2007	24.0
1958	30.0	1983	46.0	2008	32.0
1959	30.0	1984	54.0	2009	33.0
1960	31.5	1985	49.5	2010	32.0
1961	33.5	1986	53.5	2011	28.0
1962	34.5	1987	52.5	2012	28.0
1963	35.0	1988	46.5	2013	28.0
1964	36.0	1989	44.5	2014	28.0
1965	37.5	1990	44.5	2015	28.5
1966	38.0	1991	40.5	2016	28.5
1967	39.0	1992	39.5	2017	26.0
1968	40.0	1993	40.0	2018	24.5
1969	40.5	1994	39.5	2019	24.5
1970	41.5	1995	36.0	2020	24.5

2.1.4 Catch limit

As the same as the previous calculation (JRT, 2019), catch limits were calculated based on the Norwegian Catch Limit Algorithm (CLA) (Aldrin and Huseby, 2007; Aldrin *et al*., 2008) considering a tuning level of 0.6. The combination of aggregations of sub-areas A, B, C and D is treated as a *Small Area*. Catch limits for the O stock are calculated for this *Small Area*. Alternative catch limits were calculated for several assumptions for the proportions of whales in this *Small Area* which are from the O stock (S0-S4 above). Results are shown in Table 6. Adjustments for differences in sex ratio from 50:50 were not required because males represent a larger proportion than females in the actual catches.

Table 6. Catch limits for the O stock of common minke whale based on the Norwegian CLA code applied to a *Small Area* (A+B+C+D), under several assumptions for the proportion of whales in this *Small Area* which are from the O stock.

Tuning level	Option S0 (all O stock)	Option S1	Option S2	Option S3	Option S4
0.6	167	150	154	135	110

2.2 Implementation Simulation Trials (ISTs)

2.2.1 Trial scenario

For western North Pacific common minke whales, stock Hypothesis A (see section 2.1.1) was considered to have the highest plausibility, so that only this hypothesis was considered. The mixture proportions of the J and O stocks in the Okhotsk Sea under this hypothesis were treated as the main uncertainties. Following the Panel recommendation made in 2019 (Review Panel, 2019), MSYR 4% (mature) and 1% (1+) were treated as the baseline values for the trials. In addition, as the same as the previous reports (JRT, 2019), the uncertainties in the past catch records, and the value of g(0) used in abundance estimation were also considered in the trials. Taking all these possibilities into account, a total of 20 simulation trials (Table 7) were conducted for each MP variant.

Trial scenarios were denoted using the format as Ann-r (nn is the trial number and r is the MSYR value). The trials A01 are baseline trials, and their specifications are almost the same as those used in the 2014 IWC SC *Implementation Review* of this species (but the CLA tuning level of 0.6 was used instead of 0.72 for tests under these trials). Trials A02 (alternative numbers of the historical catches and bycatches), A03 (assuming g(0)=1 for abundance estimates), and A04-10 (alternative proportions of J and O stock whales in the Okhotsk Sea) were conducted for testing robustness to major uncertainties. All trials were conducted for both MSYR 4% (mature) and 1% (1+) (Ann-4 or Ann-1), and the results were treated as medium weight when deciding the acceptability of the variants.

Table 7. List of trials conducted for western North Pacific common minke whale.

Trial numbers	*MSYR*	Description	Trial weight
A01-1	1%(1+)	Baseline two stock scenario, *g*(0)=0.8, Chinese bycatch	M
A01-4	4%(mature)		M
A02-1	1%(1+)	High direct catches and alternative Korean and Japanese bycatches	M
A02-4	4%(mature)		M
A03-1	1%(1+)	Assuming *g*(0)=1	M
A03-4	4%(mature)		M
A04-1	1%(1+)	10% J stock in sub-area 12SW in August (20% in base case)	M
A04-4	4%(mature)		M
A05-1	1%(1+)	30% J stock in sub-area 12SW in August (20% in base case)	M
A05-4	4%(mature)		M
A06-1	1%(1+)	40% J stock in sub-area 12SW in August (20% in base case)	M
A06-4	4%(mature)		M
A07-1	1%(1+)	10% J stock in sub-area 12 in August	M
A07-4	4%(mature)		M
A08-1	1%(1+)	20% J stock in sub-area 12 in August	M
A08-4	4%(mature)		M
A09-1	1%(1+)	30% J stock in sub-area 12 in August	M
A09-4	4%(mature)		M
A10-1	1%(1+)	40% J stock in sub-area 12 in August	M
A10-4	4%(mature)		M

2.2.2 Data and assumptions

Data used in the conditioning and *ISTs* are summarized in ANNEX 3.
In addition to the new abundance estimates in ANNEX 1 and 2, revised previous abundance estimates were used for the conditioning and the trials. These previous estimates were revised following the revised *IST* specifications made by IWC SC/68C meeting (IWC, 2021) and subsequent works through communications with the IWC Secretariat. Thus, these previous estimates are the same as those to be used in the ongoing IWC SC *in-depth assessment* of western North Pacific common minke whales. The detailed number of the direct catches by year, sub-area and sex were also updated through communications with the IWC Secretariat, to be consistent with those used by IWC SC. The information for the incidental catches were revised following the IWC SC revised *IST* specifications. The Q matrix, QB matrix and time invariant fixed proportions by stocks to be used in removing future commercial catches from sub-areas 7CS and 7CN were updated as well with additional data being collected from ongoing commercial whaling operations and bycatch data and samples. For details, see ANNEX 3.

The biological parameters (natural mortality, age-at-maturity) and the technological parameters (selectivity) are the same as for the previous *Implementation Review* conducted by IWC SC (IWC, 2014). An age and sex-structured Pella-Thomlinson model was used to model the population dynamics of the J and O stocks common minke whales. Details of the model are provided in IWC (2014).

2.2.3 Conditioning

Data used for conditioning involved proportions of whales in various sub-areas that belonged to the J stock, abundance estimates by sub-area and estimated numbers of incidental catches. See ANNEX 3 for more details.

Conditioning plots (including fits to the abundance estimates and bycatch series) were produced and inspected for any unexpected behavior. Based on these plots, the fits were all considered to be satisfactory.

2.2.4 Future survey plan

Tables 8a and 8b show the assumed future sighting survey plan during 2021-2032 in the Sea of Japan, the North Pacific, and the Okhotsk Sea. The same pattern is to be repeated every six years.

Table 8a. Future sighting survey plan assumed for 2021-2032 in sub-areas 5, 6 and 10 (Sea of Japan).

	5	6W	6E	10W	10E
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	-	-	-	-
2024	-	-	Jun-Jul*	Jun-Jul	Jun-Jul*
2025	-	-	-	-	-
2026	-	-	-	-	-
2027	-	-	-	-	-
2028	-	-	-	-	-
2029	-	-	-	-	-
2030	-	-	Jun-Jul*	Jun-Jul	Jun-Jul*
2031	-	-	-	-	-
2032	-	-	-	-	-

* Surveys covered parts of 6E and 10E

Table 8b. Future sighting survey plan assumed for 2021-2032 in sub-areas 7, 8, 9, 11 and 12 (North Pacific and Okhotsk Sea).

	7CS	7CN	7WR	7E	8	9	11	12SW	12NE
2021	-	-	-	-	-	-	-	-	Aug-Sep**
2022	Aug-Sep	Aug-Sep	Aug-Sep	Aug-Sep	-	-	-	-	Aug-Sep**
2023	-	-	-	-	-	-	Aug-Sep	Aug-Sep	-
2024	-	-	-	-	Aug-Sep	Aug-Sep	-	-	-
2025	-	-	-	-	-	-	-	-	Aug-Sep**
2026	-	-	-	-	-	-	-	-	Aug-Sep**
2027	-	-	-	-	-	-	-	-	Aug-Sep**
2028	Aug-Sep	Aug-Sep	Aug-Sep	Aug-Sep	-	-	-	-	Aug-Sep**
2029	-	-	-	-	-	-	Aug-Sep	Aug-Sep	-
2030	-	-	-	-	Aug-Sep	Aug-Sep	-	-	-
2031	-	-	-	-	-	-	-	-	Aug-Sep**
2032	-	-	-	-	-	-	-	-	Aug-Sep**

** Surveys covered different parts of 12NE each year

2.2.5 Management variants

The Management variants were not changed from the previous report (JRT, 2019). Whaling is to be conducted in sub-areas 7CS, 7CN, 7WR and 11 within Japan's EEZ. Catch limits are to be calculated treating sub-areas 7, 8, 9, 11 and 12 as a *Small Area*, with the catches taken from sub-areas 7CS, 7CN, 7WR and 11. As the same as the previous calculation (JRT, 2019), there are four factors considered to define the variants (for convenience, the variants examined in the trials are represented by four-digit numbers):

Abundance estimates for using in actual CLA.
There are five options to calculate abundance estimates as inputs for the CLA. One is to sum over abundance estimates for sub-areas 7, 8, 9, 11 and 12 (hereafter, this option is termed All O stock or S0). Given that there may be some J stock animals in this aggregation of sub-areas, the assumed proportion in each aggregation sub-area consisting of O stock whales was multiplied by the abundance estimates in order to obtain approximate abundances of the O stock in each sub-area (options S1-S4 in Tables 1

and 3).

Whaling: Spatial closure
Two options for spatial closure are considered: i) no whales are to be taken in waters within 10nm from the coast in sub-areas 7CS and 7CN, and ii) no spatial closure. Past studies have shown that the proportion of the whales that are from the J stock is higher within 10 n.miles from the coast than that from offshore (i.e. more than 10 n.miles away from the coast) (IWC, 2014).

Whaling: temporal closure
Two options for temporal closure are considered: i) whaling is to be restricted to the period April-October in sub-areas 7CS, 7CN and 7WR, and to the period August to October in sub-area 11, and ii) whaling occurs in all months.

Allocation of catch limit
Alternative allocations of the catch limit to the four coastal sub-areas are investigated. One is the application of *Catch Cascading*. The other option is assigning catch proportions to the sub-areas as set out in Table 9).

Table 9. Proportions (%) of the catch allocated to sub-areas 7CS, 7CN, 7WR and 11

	Opt1	Opt2	Opt3	Opt4	Opt5
7CS	40	100	0	0	0
7CN	20	0	100	0	0
7WR	20	0	0	100	0
11	20	0	0	0	100

ID representing the variants.
With a combination of four factors, a total of 120 variants (5 sets of abundance estimate × 2 spatial options × 2 temporal options × 6 catch limit allocation) were examined for the 20 trials listed in Table 7. For convenience, those variants are represented by four-digit numbers (Vxxxx) as shown in Table 10.

Table 10. Variant ID for the trials for common minke whales.

Factor		
Abundance for CLA	Thousand's place (Vx***)	0: All O stock; 1: S1; 2: S2; 3: S3; 4: S4
Spatial closure	Hundred's place (V*x**)	0: Closure within 10n.m in 7CS and 7CN; 1: No closure
Temporal closure	Ten's place (V**x*)	0: Restriction of whaling season; 1: No restriction
Catch Allocation	One's place (V***x)	0: Catch cascading; 1: Opt1; 2: Opt2; 3: Opt3; 4: Opt4; 5: Opt5

For example, V0001 means the variant with all O stock abundance option, spatial closure option, temporal restriction option, and catch allocation Opt1. V1011 means the variant with S1 abundance option, spatial closure option, no temporal restriction option, and catch allocation Opt1.

2.2.6 Conservation performance

The conservation performance for each trial and variant was examined using the IWC SC's guidelines to determine whether each combination of variant and trial is classified as 'acceptable', 'borderline' or 'unacceptable'. There are two conservation performance statistics for each of the two stocks. They are the final depletion and the minimum depletion ratio (the minimum over each of the 100-year projections of a trial of the ratio of the population size to that when there are only incidental catches) (IWC, 2012).

To construct thresholds of the acceptability, equivalent single stock trials were conducted for *MSYR*(1+)=1%. The tuning levels of 0.6 and 0.48 were used because the catch limit calculation was based on the 0.6 tuning level.

It should be noted that, for the O stock, results were "acceptable" (A) for all the trials and variants. This implies that there is no problem with conservation performance for the O stock under any variant. Where unacceptability occurs, this is a consequence of "unacceptable" performance for the J stock.

It also should be noted that for the scenarios with *MSYR*(mat)=4%, results were "acceptable" (A) for most of the trials and variants, and "borderline" (B) for the rest.

Table 11. Summary of trial results for variants S0 (V0xxx: all O stock option) which were borderline or showed unacceptable performance.

Variant	Borderline trials	Unacceptable trials	Recommendation
V0000	A01-1, A04-1	A03-1	Unacceptable
V0001	None	None	Acceptable
V0002	None	None	Acceptable
V0003	None	None	Acceptable
V0004	None	None	Acceptable
V0005	A03-4, A08-1	A01-1, A02-1, A03-1, A04-1, A05-1, A06-1, A07-1	Unacceptable
V0010	A01-1, A04-1	A03-1	Unacceptable
V0011	None	None	Acceptable
V0012	None	None	Acceptable
V0013	None	None	Acceptable
V0014	None	None	Acceptable
V0015	A01-1, A02-1, A03-1, A04-1, A05-1, A06-1, A07-1	A03-4, A08-1	Unacceptable
V0100	A01-1, A04-1, A05-1	A03-1	Unacceptable
V0101	A03-1	None	Acceptable
V0102	None	A03-1	Unacceptable
V0103	None	None	Acceptable
V0104	None	None	Acceptable
V0105	A01-1, A02-1, A03-1, A04-1, A05-1, A06-1, A07-1	A03-4, A08-1	Unacceptable
V0110	A01-1, A04-1, A05-1	A03-1	Unacceptable
V0111	A03-1	None	Acceptable
V0112	A03-1	None	Acceptable
V0113	None	None	Acceptable
V0114	None	None	Acceptable
V0115	A01-1, A02-1, A03-1, A04-1, A05-1, A06-1, A07-1	A03-4, A08-1	Unacceptable

Although all 20 trials with 120 variants were conducted, only the results of the trials for variants with S0 (i.e., all O stock option) are shown in Table 11. If the results of the trials are "acceptable" for S0 option, other options used to calculate abundance estimate for the use of CLA (options S1, S2, S3 and S4) would also be "acceptable" because the future catch should be lower than those in the S0 option.

Regarding the spatial closure options, the number of acceptable variants with option i) is more than those with option ii) (Table 11), indicating that spatial closure is an effective management measure for the western North Pacific common minke whale. Therefore, variants with option i) (i.e., no whales will be taken in waters within 10nm from the coast in sub-areas 7CS and 7CN) is to be adopted.

Regarding the temporal option, the number of acceptable variants is similar for option i) and option ii), indicating that temporal closure is not a useful management measure.

As regards allocation of the catch among the sub-areas 7CS, 7CN, 7WR and 11, catch cascading and option 5 (variant ID with '0' or '5' in the "One's place" – see Table 10) are unacceptable. As seen in the previous IWC SC Implementation Review (IWC, 2014, Table 4a in appendix2 of ANNEX D1), catch cascading allocates a higher proportion of the catch to sub-area 11 than catch allocation options 1-4 do. Given that the proportion of the whales in sub-area 11 that are from the J stock is higher than in sub-areas 7CS, 7CN and 7WR, these two options would lead to bigger catch from the J stock than other options, and this is the reason why these options are unacceptable. Options 1, 2, 3 and 4 for catch allocation are acceptable whenever no whales are to be taken in waters within 10nm from the coast in sub-areas 7CS and 7CN (V0001, V0002, V0003, V0004, V0011, V0012, V0013 and V0014). This means a) up to 20% of catch limits can be allocated to sub-area 11, and b) any of the allocation pattern suggested among sub-areas 7CS, 7CN and 7WR is acceptable.

In conclusion, V0001 to V0004, V0011 to V0014, V0101, V0103 to V0104, and V0111 to V0114 are 'acceptable' for both J and O stocks.

3. WHALING OPERATIONS AND FUTURE SURVEY

Considering the results of the trials, Japan is to adopt the "all O stock" option (S0) for the abundance estimate used for the CLA and to set at 167 as a revised catch limit for western North Pacific common minke whales. Following the acceptable management variants, a 10-mile spatial closure is to be introduced on the Pacific side of Japan to decrease the catch of J stock whales. Twenty percent of catch limit is to be allocated to sub-area 11, while 80% of the catch is to be allocated to the Pacific side of Japan (a block quota for sub-areas 7CS, 7CN and 7WR). Revised catch limit is to be considered to set the catch quota in 2022. When setting the catch quota for the commercial whaling, average number of bycatches caught by set nets in the recent 5 years is to be deducted from the catch limit as the same as the current management measures. In addition, a part of the catch quota is reserved by the Fisheries Agency of Japan (FAJ) for the purpose of necessary adjustments, if necessary, such as a transfer of catch quota allocated to different fishery types, and/or to control operation periods during the fishery season. The total catch quota including FAJ's reserves is to be set within the catch limits.

For monitoring the exploited stock and improving specification of the scenarios to be considered in future trials, collection of biological data and samples from harvested whales in the commercial whaling are to be conducted as shown in Table 12. These biological surveys are to be continued, and data and samples will be duly examined at the full assessment for updating catch limit which planned tentatively in a six years-period. Further, future sighting surveys for revising abundance estimates for the use in the full assessment will be also conducted in line with the options shown in section 2.2.4.

Table. 12. Biological data and samples collected from harvested common minke whales taken by commercial whaling in 2019 and 2020.

		2019*					2020						
		Land-based whaling		Pelagic whaling			Land-based whaling						
		7CN		7WR			7CS		7CN		11		
Objectives	Data and samples	Male	Female	Male	Female	Total	Male	Female	Male	Female	Male	Female	Total
Fundamental information	Catching date and location	24	9	10	1	44	1	5	58	25	4	2	95
	Sex and body length	24	9	10	1	44	1	5	58	25	4	2	95
Stock identification	Photographic record for external body character	24	9	10	1	44	1	5	58	25	4	2	95
	Body scar record	24	9	10	1	44	1	5	58	25	4	2	95
	External body proportion	17	4	10	1	32	1	5	58	25	3	1	93
	Skin tissues for DNA analysis	24	9	10	1	44	1	5	58	25	4	2	95
Age determination	Earplug for age determination	24	9	10	1	44	1	5	58	25	4	2	95
	Eye lens for age determination	24	9	10	1	44	1	5	58	25	4	2	95
	Collection of Baleen plate	1	1	0	0	2	1	5	3	4	1	1	15
Reproductive information	Mammary grand; lactation status and measurement	-	9	-	1	10	-	5	-	25	-	2	32
	Uterine horn; measurements and endometrium sample	-	2	-	0	2	-	5	-	22	-	2	29
	Collection of ovary	-	6	-	1	7	-	5	-	21	-	2	28
	Testis; weight and histological sample	24	-	9	-	33	1	-	58	-	4	-	63
	Photographic record of foetus	2	0	0	0	2	0	0	3	9	1	0	13
	Foetal sex, length and weight	2	0	0	0	2	0	0	3	9	1	0	13
	Skin tissues for DNA study of foetus	2	0	0	0	2	0	0	3	9	1	0	13
	Eye lens of foetus for age determination	1	0	0	0	1	0	0	3	8	1	0	12
Ecological monitoring	Measurements of blubber thickness	24	9	10	1	44	1	5	58	25	4	2	95
	Stomach contents, convenient record	24	9	10	1	44	1	5	58	25	4	2	95
	Collection of stomach contents for feeding study	0	0	0	0	0	0	0	0	0	0	0	0
	Muscle, liver, blubber and skin for various analysis	24	9	10	1	44	1	5	58	25	4	2	95

*In addition to the above, a total of 47 animals in sub-area 7CS, and 32 aminals in sub-area 11were taken and sampled in 2019 by the NEWREP-NP before staring the commercial whaling. Detailes for those data and samples were listed in the cruise reports submiitted to the 68B IWC/SC (SC/68B/O/04 and SC/68B/O/05).

REFERENCES

Aldrin, M. and Huseby, R.B. 2007. Simulation trials 2007 for a re-tuned Catch Limit Algorithm. Paper SC/59/RMP/4 presented the 59 IWC Scientific Committee in 2007.

Aldrin, M., Huseby, R.B. and Schweder, T. 2008. A note on tuning the Catch Limit Algorithm for commercial baleen whaling. *J. Cetacean Res. Manage*. 10 (3): 191-194.

Fisheries Agency of Japan. 2019a. Setting Catch Quotas of large whales for Commercial Whaling. https: //www.jfa.maff.go.jp/j/whale/attach/pdf/index-48.pdf

Fisheries Agency of Japan. 2019b. Resumption of Commercial Whaling. https://www. jfa.maff.go.jp/e/ whale/attach/pdf/index-5.pdf

Gushcherov P.S., Tyupeleev P.A., Blokhin S.A., Shkarupa M.A., Samonov V.I. and Miyashita T. 2017. Cruise report of the cetacean sighting survey in the northern part of the Sea of Okhotsk in 2016. Paper SC/67a/ASI/03 presented the 67a IWC Scientific Committee in 2017.

Gushcherov P.S., Tyupeleev P.A., Shkarupa M.A., Makrak S.V., Samonov V.I. and Miyashita, T. 2018. Cruise report of the cetacean sighting survey in the eastern part of the Sea of Okhotsk in 2017. Paper SC/67b/ASI/17 presented the 67b IWC Scientific Committee in 2018.

Gushcherov P.S., Tyupeleev P.A., Naberezhnykh I.A., Makrak S.V., Samonov V.I. and Miyashita, T. 2019. Cruise report of the cetacean sighting survey in the north-west part of the Sea of Okhotsk in 2018. Paper SC/68a/ASI/12 Rev1 presented the 68a IWC Scientific Committee in 2019.

Gushcherov, P.S., S.A., Naberezhnykh I.A., Bashtovoy A.N., Novozhilov A.A., V.I. Samonov and Miyashita, T. 2020. Cruise report of the cetacean sighting survey in the west part of the Sea of Okhotsk in 2019. Paper SC/68b/ASI/12 Rev1 presented the 68b IWC Scientific Committee in 2020.

Gushcherov, P.S., S.A., Naberezhnykh I.A., Tyupeleev, P.A., Novozhilov A.A., V.I. Samonov and Miyashita, T. 2021. Cruise report of the cetacean sighting survey in the central part of the Sea of Okhotsk in 2020. Paper SC/68c/ASI/12 presented the 68c IWC Scientific Committee in 2021.

International Whaling Commission. 2012. Requirements and Guidelines for Implementations under the Revised Management Procedure (RMP). *J. Cetacean Res. Manage*. 13 (suppl): 495-506.

International Whaling Commission. 2014. Report of the Scientific Committee, Annex D1. Report of the Working Group on the Implementation Review for Western North Pacific Common Minke Whales. Appendix 2. North Pacific minke whale *Implementation Simulation Trial* Specifications. *J. Cetacean Res. Manage*. 15 (suppl.):112-188.

International Whaling Commission. 2020a. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Implementation Reviews and Simulation Trials. J. *Cetacean Res. Manage*. 21 (suppl.):77-206.

International Whaling Commission. 2020b. Report of the Scientific Committee, Annex Q. Report of the Standing Working Group on Abundance Estimates, Stock Status, and International Cruises. *J. Cetacean Res. Manage*. 21 (suppl.):277-299.

International Whaling Commission. 2021. Report of the Scientific Committee, Annex D. Revised Specifications for Western North Pacific Minke Whales. *J. Cetacean Res. Manage*. (in press).

Japan's RMP Team. 2019. Catch limits for western North Pacific sei, Bryde's and common minke whales calculated in line with the IWC's Revised Management Procedure (RMP). https://www.jfa.maff. go.jp/e/whale/attach/pdf/index-14.pdf

Katsumata, T., Yoshimura, I., Tsunekawa, M., Kawabe, S. and Matsuoka, K. 2020. Results of the Japanese dedicated cetacean sighting survey in the western North Pacific in 2019 and 2020. Paper SC/68B/ASI/18 presented the 68b IWC Scientific Committee in 2020.

Katsumata, T., Yoshida, T., Isoda, T., Yamaguchi, F., Yamazaki, M., Takahashi, M., Murata, H. Matsuoka, K. 2021. Results of the Japanese dedicated cetacean sighting survey in the western North Pacific in 2020 summer season. Paper SC/68C/ASI/14 presented the 68c IWC Scientific Committee in 2021.

Matsuoka, K., Hakamada, T., Yoshimura, I., Katsumata, T., Kasai, H. and Miyashita, T. 2019. Results of Japanese dedicated cetacean sighting survey in western North Pacific. Paper SC/68A/ASI/03 presented the 68a IWC Scientific Committee in 2019.

Miyashita, 2019. Abundance Estimate of common minke whales in sub-areas 11, 10E and 7CN in 2014. Paper SC/68A/ASI/15 presented the 68a IWC Scientific Committee in 2019.

Murase, H., Katsumata, T., Yoshimura, I., Fujii, S., Abe, N. and Matsuoka, K. 2021. Cruise report of the 2020 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Paper SC/68C/ASI/05 presented the 68c IWC Scientific Committee in 2021.

Myasnikov V. G., Vinnikov A. V., Ryabov A. A., Tyupeleev P.A., Gushcherov P.S., Samonov, V.I., and Miyashita T. Cruise report or the cetacean sighting survey in the norther Okhotsk Sea in 2015. Paper

SC/66b/IA/17 presented the 66b IWC Scientific Committee in 2016.
Okamura, H., Miyashita, T. and Kitakado, T. 2010. g(0) estimates for western North Pacific common minke whales. Paper SC/62/NPM/9 presented the 62 IWC Scientific Committee in 2010.
Review Panel. 2019. Report from the group of independent scientists requested to review the proposal from Japanese scientists for catch limits for Japanese commercial whaling. https://www.jfa.maff. go.jp /e/whale/attach/pdf/index-11.pdf

ANNEX 1

Abundance estimates of common minke whales in sub-area 12NE using sighting data collected by Russia-Japan cooperative sighting survey during 2015-2020

Tomio Miyashita
Fisheries Resources Institute
Japan Fisheries Research and Education Agency
5-7-1 Orido, Shimizu-ku, Shizuoka-shi, Shizuoka, 424-8633 Japan
e-mail: miyachan@affrc.go.jp

ABSTRACT
Abundance of common minke whales in sub-area 12NE was estimated from the sighting data collected by the Russia-Japan cooperative sighting surveys during 2015 to 2020. The smearing method was applied to reduce the effect on detection model fitting of the rounding error in degree estimation. The perpendicular distance was truncated at 0.8 n. miles and multi covariates considered were wind force and visibility. Hazard rate model with visibility was the best fitted model selected by AIC, and the resultant abundance estimates was 15,621 (CV: 0.419, 95% CI: 7,106 – 34,340). Survey coverage was 89% in sub-area 12NE. Year 2018 can be considered as the time stamp based on the weighted mean by research distance. Abundance estimates in this study can be used for the revision of catch limit calculation for sustainable commercial whaling of common minke whales being planned by Japan.

INTRODUCTION

The sighting survey in the Sea of Okhotsk including the Russian Exclusive Economic Zone (EEZ) was firstly conducted in 1989 by a Japanese research vessel (Miyashita and Zharikov, 2013). Since then, Japan has applied for permission to enter the Russian EEZ and has conducted sighting surveys when permission was approved. However, in the mid-1990's, a restricted area for survey was set by Russia in its north-eastern coastal areas, which has been expanded with time (Figure 1). As a consequence, Japanese research vessels could not conduct sighting surveys in the restricted area and the abundance in such area has been treated as zero in the past International Whaling Commission/Scientific Committee (IWC/SC) Revised Management Procedure (RMP) *implementation*.

Considering the high density of common minke whales in the restricted area revealed from previous surveys (Miyashita and Zharikov, 2013) (Figure 2), Japan called on Russia to cooperate on sighting survey in the Sea of Okhotsk including the restricted area using a Russian research vessel in early 2010's. As a result to this call, the first survey was conducted in 2015 (Myasnikov *et al.*, 2016). Since then, the cooperative surveys have been conducted every year under IWC/SC oversight (Gushcherov *et al.*, 2017; 2018; 2019; 2020; 2021). Under nomination by the IWC/SC, the author acted as the oversight scientist of the surveys on behalf of the IWC. Also, the author participated in the survey during the first three years (2015-17).

This report presents the abundance estimates of common minke whales in sub-area 12NE based on the Russia-Japan cooperative surveys. The new estimates can assist in the revision of the catch limit calculations for sustainable commercial whaling of this species planned by Japan.

MATERIALS AND METHODS

Research vessel
The annual surveys were conducted by the same vessel, *Vladimir Safonov*. The vessel is equipped with a barrel of 15m high from the sea surface (Gushcherov, 2021) (Figure 3).

Survey period

All surveys during 2015-2020 were conducted from early August to early September falling within the time frame of the past minke whale sighting surveys in the Sea of Okhotsk.

Survey blocks and mode

A total of seven blocks were set in sub-area 12NE (Figure 4). In principle, one block was covered in one year. This strategy was adopted because of the limited number of days determined for each annual survey (35 days). Division into seven blocks was made taking into account of the seafloor topography and the availability of days for survey (35 days), which limited the extension of the areas to be surveyed each year. Blocks b, c and d correspond to the restricted area set by Russia since mid-1990's (Figures 1 and 4). In 2015 feasibility/training surveys were conducted in blocks a and b. In 2016, the vessel conducted a full-scale survey in blocks b and c. Subsequent full-scale surveys were conducted in block d in 2017, block e in 2018, block f in 2019, and block a in 2020.

The pre-determined track line were set using DISTANCE (Thomas *et al.*, 2010). To avoid double counting, generally the surveys were conducted from north to south considering the migration direction of whales. The general sighting methodology is similar to that used by the IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) sighting survey, which follows the IWC guidelines (IWC, 2012).

Two observers conducted sighting regularly from the barrel. The surveys in the research area were conducted using closing mode for large whales under the suitable weather conditions (wind force less than four and visibility longer than 2 n. miles). Observers used naked eyes for primary observations, and a binocular was used as a supplement for confirmation of sightings such as species identification and school size estimation.

Analytical procedures

The g (0) was assumed to be 1.0 in the subsequent analyses because the single platform in the vessel did not allow for estimation of g(0).

Before analysis of perpendicular distance distribution, a rounding error in the estimation of degree was found for the data from 2016 to 2019 (Figure 5). Angle board was used to assist the estimation of degree from the beginning of the project in 2015, but the reason for the rounding error seems to be that the use of the tool was not thorough since 2016. To reduce the impact of the rounding error in the analysis, the smearing method II (Buckland and Anganuzzi, 1988) was applied to the data. In 2020, the author pointed out the rounding error found in the past seasons to the Russian observers before starting the survey. Since that year, observers have been using the tool correctly and rounding errors have been reduced substantially, but the smearing was applied to all data from 2015 to 2020.

Analyses were carried out using Multiple Covariate Distance Sampling (MCDS) Engine in Distance 7.3 Release 1 (Thomas *et al*., 2010) and the abundance was estimated based on detection probability in a Horvitz-Thompson-like estimator. The basic models for fitting the perpendicular distribution were Half normal (HN) and Hazard-rate (HR), and as covariates, weather conditions (wind force and visibility) were considered. AIC was used to select the best model.

RESULTS AND DISCUSSION

In total, coverage in sub-area 12NE was 89%.

A total of 59 schools (75 animals) of common minke whales were sighted in the research area and during transit (Table 1). In the research area, 45 schools (66 animals) were sighted as primary sightings. The sighting positions in the research area are shown in Figure 6.

Because the same vessel was used and the observers onboard remained almost the same from the beginning of the project, all primary sightings in the research area (45 schools) and during transit (14 schools) were lumped together and used for the estimation of detection function. Before lumping, perpendicular distances were compared by season. The median of perpendicular distances was almost same among seasons but with slightly larger values in the recent two seasons (2019 and 2020) (Table 2). The reason for this is unclear although the small sample sizes should be noted. The different values could be due to differences in weather conditions, so weather conditions were taken into account as covariates in the estimation. In block b, the abundance estimate was done by adding data from 2015 and 2016. This was done because of the low coverage in both surveys (66% in 2015 and 41% in 2016) due to bad weather.

The smearing parameters were estimated as φ=7.5 and s'=0.926 which were like those for Antarctic minke whales estimated in Buckland and Anganuzzi (1988). After smearing parameter estimation for the data, the perpendicular distance distribution was plotted as Figure 7. To exclude the outliers sighted at long distance, perpendicular distance was truncated at 0.8 n. miles for the analysis and two schools in 59 schools (3.3%) were excluded from estimation of detection function. Perpendicular distances for species other than common minke whales are shown in Figure 8 (see discussion below).

Before the analysis, the relationship between the perpendicular distance and candidates of covariates (wind force and visibility) were examined (Figure 9). Based on the results of a possible relationship suggested in these figures, wind force and visibility were selected as covariates.

A summary of model selection by AIC is shown in Table 3. The best fitted model was Hazard-rate model with covariate of visibility. The fitting of the detection function curve is shown in Figure 10 and the Q-Q plot in Figure 11. The model seems to fit well.

The area size, encounter rate and mean school size are shown in Table 4. Density estimate of schools is shown in Table 5. The expected school sizes based on the Horvitz-Thompson-like estimator were shown in Table 6. Abundance estimates based on this information were shown in Table 7. Total abundance estimate was 15,621 (CV: 0.419, 95% CI: 7,106 – 34,340).

The perpendicular distance distribution seems to have some spike (Figure 7). Possible reasons for spike are (1) animals closed to the vessel before findings, (2) observers' effort may be skewed toward the track line. Currently, there is no data to evaluate the plausibility of (1) above. However, the plausibility of (2) above can be examined comparing the perpendicular distance distribution of the sightings for other species (dolphins and large whales other than common minke whales) (Figure 8). Other species sightings occurred at wider perpendicular distance, and this suggests a wide range of observations, which suggest that the plausibility of (2) above is low.

In order to interpret the spike observed, perpendicular distance distributions in previous surveys were examined (see Appendix 1). When binoculars were used for observation of common minke whales before the mid-1990's, perpendicular distance had wider distribution. On the other hand, when naked eyes were used since late1990's, perpendicular distances had a narrower distribution. Although a strict definition of spike has not been established, the phenomenon of high numbers in the head direction were also observed in the past. Therefore, it seems that the spike phenomenon is not always present, but it is expected to appear once in a while.

Additional variance should be considered when the multi year's data were used for the abundance estimate. For example, additional variance was introduced for North Atlantic common minke whales (Skaug, 1999), Antarctic minke whales (Punt *et al.*, 1997) and North Pacific Bryde's whales (Kitakado *et al.*, 2005). However, the situation in the Sea of Okhotsk was different because no surveys had been conducted in some areas for a long time (longer than 30 years). This was explained in part by Russian regulations restricting surveys in some particular areas as mentioned before. Because we have no information in the restricted area when the adjoining area is surveyed, we cannot investigate the impact on the restricted area. Also, the figures of blocks have been changed during these years due to the expansion of the restricted area. Then further examination should be necessary to estimate additional variance in the case of the Sea of Okhotsk, but it is difficult to estimate before additional surveys are conducted. Details are shown in Appendix 2.

The present abundance estimation can be compared to those in the past studies (Table 8). As mentioned before, the research area has been limited due to the restricted area by Russia for a long time. The entire sub-area 12NE has been covered in 1989 and 1990 without restriction, and the surveys in 1999 and 2003 covered this sub-area only partially. The survey coverage in the period 2015-2020 was 89% (Figure 12).

In this analysis g (0) was assumed as 1. However considering that the top barrel is not too high and the usage of naked eyes for observation, it is reasonable to assume that g(0) is less than 1. However, for various reasons, such as the inability to install an independent observer platform, it would be impossible to conduct IO mode survey on *Vlavimir Safonov* and to estimate g (0). The past abundance estimates were obtained from the Japanese catcher boat type research vessels with a top barrel that was 18-20m height from the sea surface level. On contrast, the present Russian research vessel has a barrel with 15m above the sea surface level. The top barrel of the Japanese research vessel has traditionally been designed for the most efficient observation, with plenty of space and sufficient visibility in all directions. On the other hand, the barrel of the Russian research vessel is located in the middle of the radar mast (not on the top) (Figure 3), and unfortunately, it would be difficult to get the same level of visibility as Japanese research vessels. Then the observers on the Japanese research vessels had a more distant view than those on the present Russian vessel, and the former vessels might be less likely to be missed than the latter generally. The season of the past Japanese surveys were mainly from August to September and included the season of the present survey. Those suggest that the g(0) estimate for the Japanese research vessel in 2003 is modest for the present Russian vessel but it seems applicable in order to compensate some of the effects of g(0) on the present estimate.

ACKNOWLEDEMENTS
I would like to express my deepest gratitude to the crew and the researchers for their tremendous efforts in conducting these surveys. Also, I thank to a dog which became a comfort during the voyage.

REFERENCES

Buckland, S.T. and Anganuzzi, A.A. 1988. Comparison of smearing methods in the analysis of minke sightings data from IWC/IDCR Antarctic Cruises. RIWC 38: 257-63.

Gushcherov P.S., Tyupeleev P.A., Blokhin S.A., Shkarupa M.A., Samonov V.I. and Miyashita T. 2017. Cruise report of the cetacean sighting survey in the northern part of the Sea of Okhotsk in 2016. Paper SC/67a/ASI presented the 67a IWC Scientific Committee in 2017.

Gushcherov P.S., Tyupeleev P.A., Shkarupa M.A., Makrak S.V., Samonov V.I. and Miyashita, T. 2018. Cruise report of the cetacean sighting survey in the eastern part of the Sea of Okhotsk in 2017. Paper SC/67b/ASI presented the 67b IWC Scientific Committee in 2018.

Gushcherov P.S., Tyupeleev P.A., Naberezhnykh I.A., Makrak S.V., Samonov V.I. and Miyashita, T. 2019. Cruise report of the cetacean sighting survey in the north-west part of the Sea of Okhotsk in 2018. Paper SC/68a/ASI presented the 68a IWC Scientific Committee in 2019.

Gushcherov, P.S., Tyupeleev, P.A., Samonov, V.I., and Miyashita, T. 2020. Research plan of the cetacean sighting survey in the central Sea of Okhotsk in 2020. Paper SC/68b/ASI11/Rev1 presented the 68b IWC Scientific Committee in 2020, Cambridge, UK, 12-24 May.

Gushcherov, P.S., S.A., Naberezhnykh I.A., Bashtovoy A.N., Novozhilov A.A., V.I. Samonov and Miyashita, T. 2020. Cruise report of the cetacean sighting survey in the west part of the Sea of Okhotsk in 2019. Paper SC/68b/ASI presented the 68b IWC Scientific Committee in 2020.

Gushcherov, P.S., S.A., Naberezhnykh I.A., Tyupeleev, P.A.,, Novozhilov A.A., V.I. Samonov and Miyashita, T. 2021. Cruise report of the cetacean sighting survey in the central part of the Sea of Okhotsk in 2020. Paper SC/68c/ASI presented the 68c IWC Scientific Committee in 2021.

International whaling commission, 2012. Requirement and guidelines for conducting surveys and analysing data within revised management scheme. *J. Cetacean Res. Manage.* 13(SUPPL) 509-517.

Kitakado, T., Shimada, H., Okamura, H. and Miyashita, T. 2005. Review of abundance estimate and additional variance for the western North Pacific stock of Bryde's whales. Paper SC/57/PFI1 presented to the IWC Scientific Committee, June 2005, Ulsan, Korea. 20pp.

Miyashita T. and Zharikov, V.I. 2013. Cetacean in the Sea of Okhotsk – results of Japan and Russia joint sighting surveys. *in* Ecosystem in the Sea of Okhotsk and its conservation. ed. by Sakurai, Y., Ohsima, K. and Ootaishi, N. Hokkaido Daigaku Shuppankai. 500pp.: 156-167. (in Japanese with English summary).

Myasnikov V. G., Vinnikov A. V., Ryabov A. A., Tyupeleev P.A., Gushcherov P.S., Samonov, V.I., and Miyashita T. Cruise report or the cetacean sighting survey in the norther Okhotsk Sea in 2015. Paper SC/66b/IAxx presented the 66b IWC Scientific Committee in 2016. 25pp.

Punt, A.E., Cooke, J.G., Borchers, D.L. and Stringberg S. 1997. Estimating of extent of additional variance for southern hemisphere minke whales from the results of the IWC/IDCR cruises.

Rep. int. Whal. Commn 47: 431-434.
Skaug, H.J. 1999. Combination of multiyear surveys for Northeastern Atlantic minke whale. Paper SC/51/RMP10 presented to the 51st IWC Scientific Committee in 1999. 4pp.
Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5-14. DOI: 10.1111/j.1365-2664.2009.01737.x

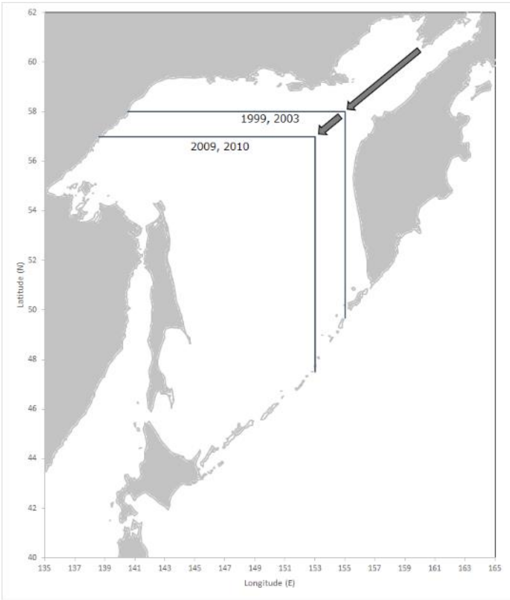

Figure 1. Expansion of restricted area in the northeastern Sea of Okhotsk.

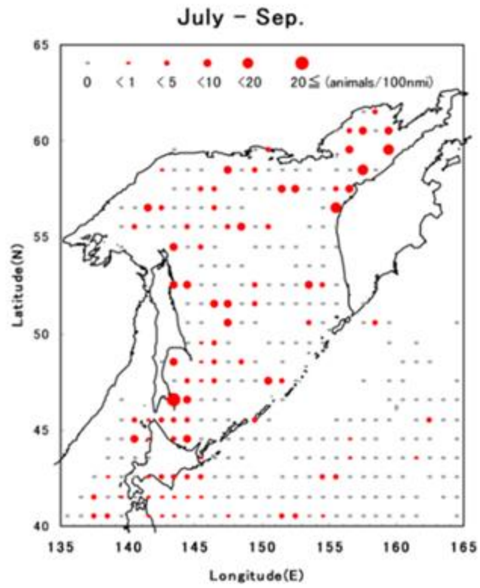

Figure 2. Density index (no. animals sighted / 100 n. miles of research distance) of common minke whales revealed from the past sighting surveys (1989-2003) (Miyashita and Zharikov, 2013).

Figure 3. Russian research vessel, *Vlamir Sofonov* (from Gushcherov *et al.,* 2021). Barrel is shown by red circle.

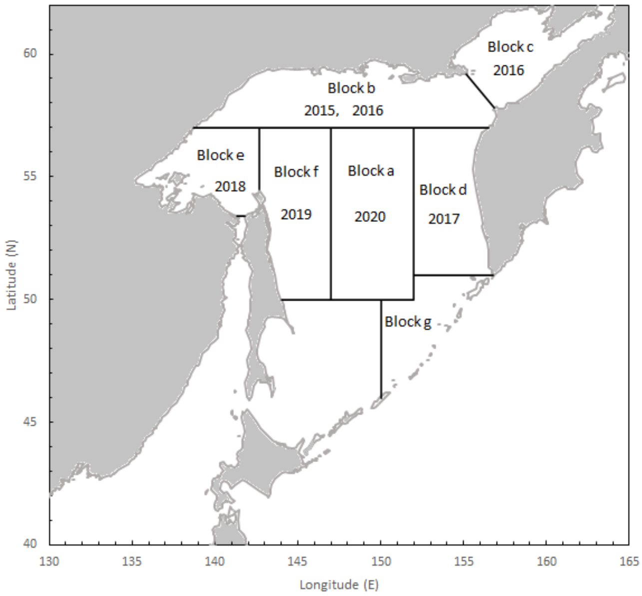

Figure 4. Blocks established in sub-area 12NE and years of surveys.

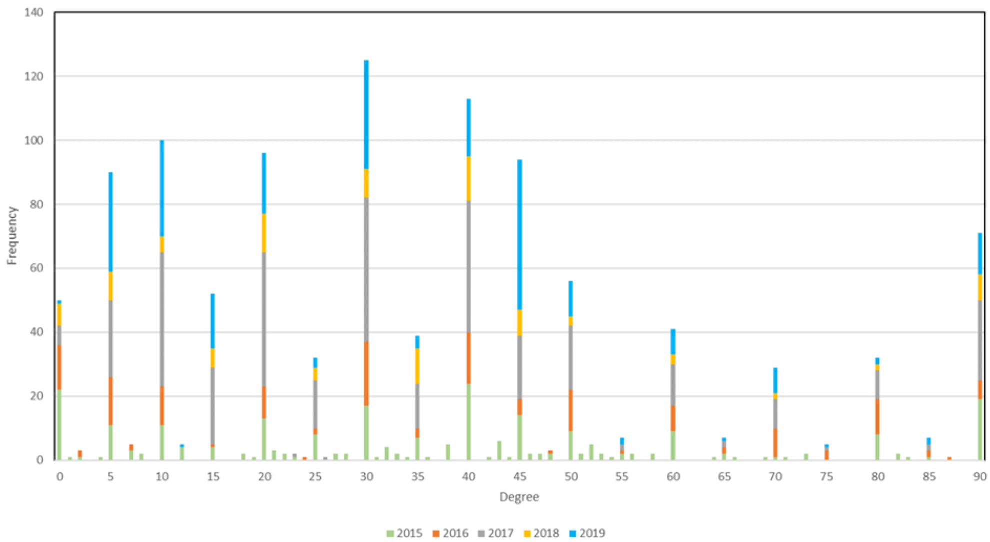

Figure 5. Frequency of angle estimates for all species primary sightings made in 2015-2019. Typical rounding error was found after 2016.

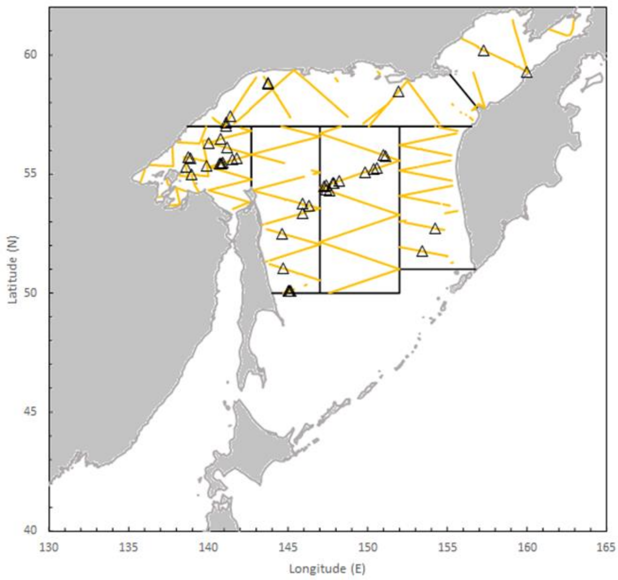

Figure 6. Sighting positions of common minke whale primary sightings (black triangle).
Line shows the track line on effort.

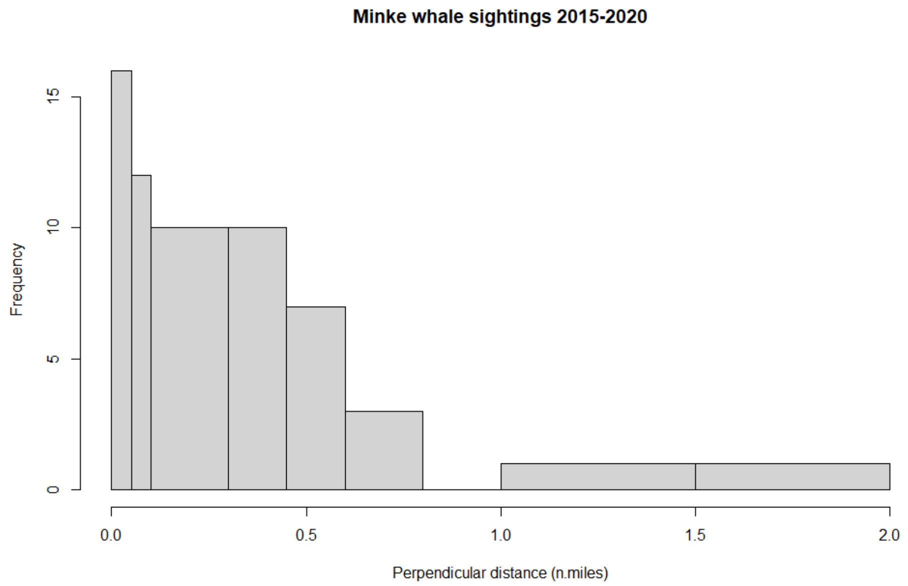

Figure 7. Perpendicular distance distribution of common minke whale sightings from 2015 to 2020. All primary sightings in the research area and during transit are included.

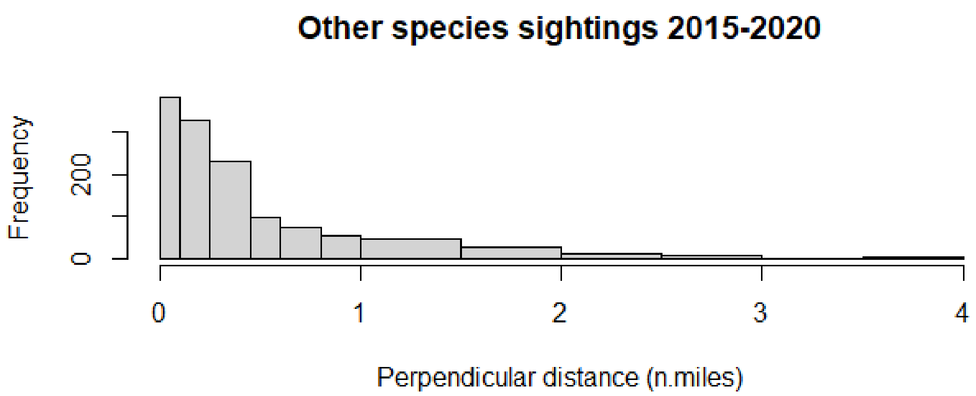

Figure 8. Perpendicular distance distribution of species other than common minke whales during 2015-2020. All primary sightings in the research area and during transit area included.

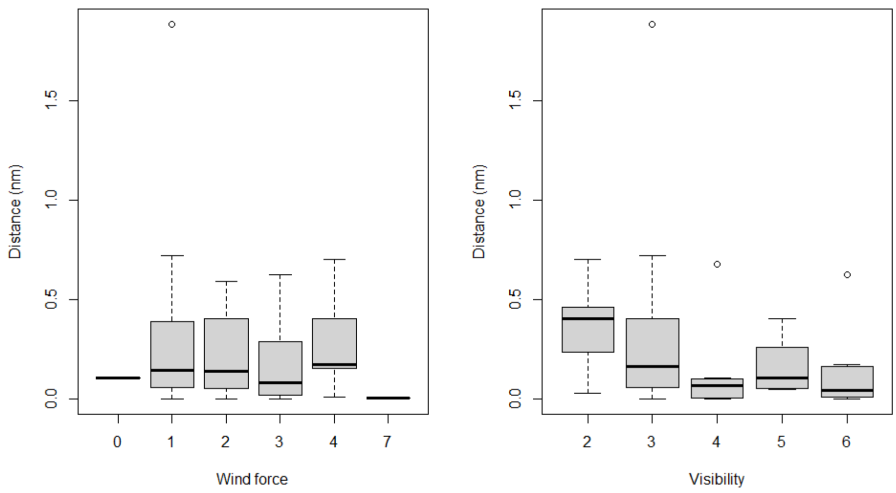

Figure 9. Relationship between perpendicular distance and wind force (left) and visibility (right) for common minke whale primary sightings.

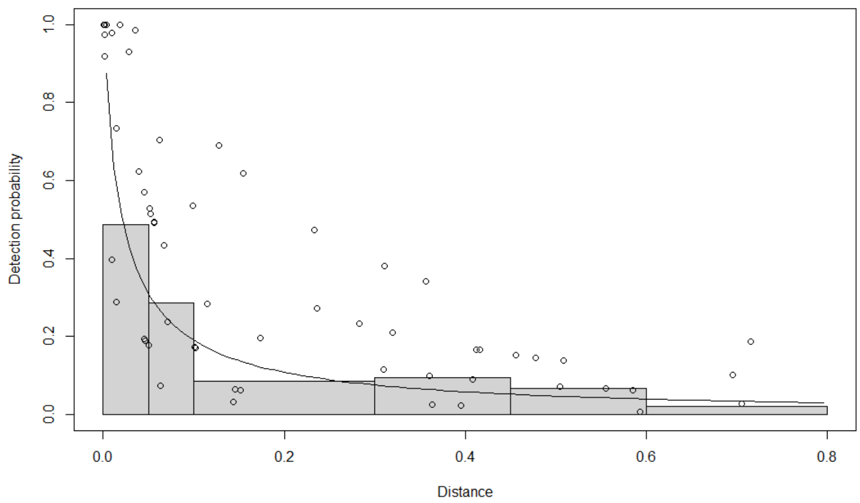

Figure 10. Detection function curve fitting for common minke whale sightings from 2015 to 2020.Circles indicate the predicted detection probability for individual detections at the recorded considering covariate. In this case, hazard rate model with visibility as covariate was selected and shown.

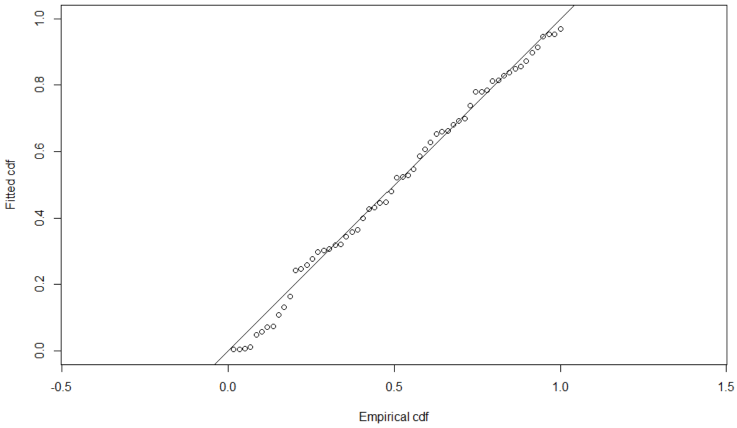

Figure 11. Q-Q plots for detection function curve.

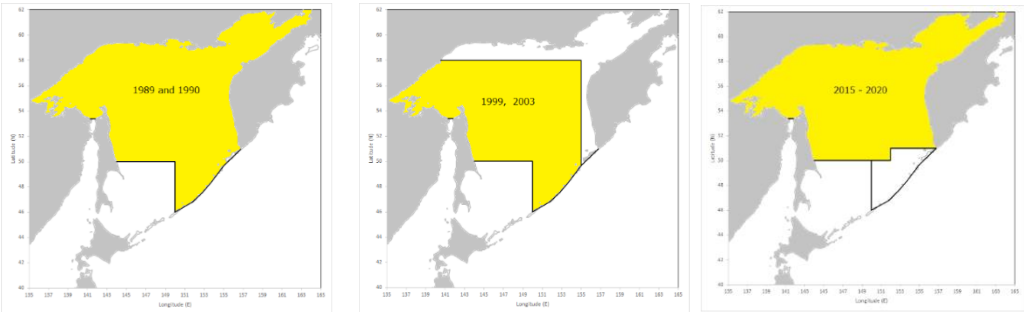

Figure 12. Coverage in the sub-area 12NE by the sighting surveys listed in Table 8. The entire sub-area 12NE was surveyed in 1989 and 1990, but since then it has been surveyed only partially.

Table 1. Research distance and number of primary sightings.

Block	Season	Research distance (nmi)			number schools	number animals
		Scheduled	Actual	%		
a	2020	1,223.1	1,223.1	100.0	11	15
b	2015-2016	1,792.3	1,034.5	52.2	6	6
c	2016	684.6	669.2	97.8	3	4
d	2017	1,488.2	885.7	59.5	2	2
e	2018	1,345.8	1,258.7	93.5	14	14
f	2019	1,562.3	1,188.4	76.1	9	15
Transit	2015-2020				14	19
Total		8,096.3	6,259.7	77.3	59	75

Table 2. Comparison of perpendicular distance of all primary sightings after smearing.

Block	Season	n	Min	Max	Median
a	2020	11	0.0039	1.8686	0.2328
b	2015-2016	6	0.0014	0.5927	0.0122
c	2016	3	0.0146	0.1011	0.0633
d	2017	2	0.0527	0.0563	0.0545
e	2018	14	0.0004	0.5855	0.0618
f	2019	9	0.0623	0.7051	0.4084
Transit	2015-2020	14	0.0020	1.5721	0.2329

Table 3. Model selection.

Model	df	AIC
Half normal	1	-56.52433
Half normal + wind	2	-54.64313
Half normal + visibility	2	-57.01956
Half normal + wind + visibility	3	-55.75406
Hazard rate	2	-74.5181
Hazard rate + wind	3	-76.17729
Hazard rate + visibility	**3**	**-77.14307**
Hazard rate + wind + visibility	4	-76.25264

Table 4. Area, effort, no sightings, encounter rate and mean school size.

Block	Area ($n.mile^2$)	CoveredArea ($n.mile^2$)	Effort (n.mile)	n	Encounter rate (ER)	se.ER	cv.ER	Mean school size	se.Mean school size
a	75,085	1,897	1,223.1	11	0.0090	0.0056	0.623	1.36	0.203
b	64,656	1,498	1,034.5	6	0.0058	0.0028	0.481	1.00	0.000
c	38,428	1,026	669.2	3	0.0045	0.0024	0.536	1.33	0.333
d	51,443	1,417	885.7	2	0.0023	0.0015	0.649	1.00	0.000
e	39,134	2,014	1,258.7	14	0.0111	0.0048	0.432	1.00	0.000
f	58,745	1,622	1,188.4	9	0.0076	0.0037	0.484	1.67	0.333

Table 5. Density estimate (no.schools/n.mile^2).

Block	Density	se	cv	95%LCI	95%UCI
a	0.027	0.021	0.779	0.006	0.127
b	0.106	0.091	0.854	0.024	0.472
c	0.055	0.042	0.766	0.014	0.223
d	0.008	0.006	0.731	0.002	0.034
e	0.048	0.025	0.532	0.018	0.129
f	0.040	0.026	0.645	0.011	0.140

Table 6. Expected school size.

Block	Expected School Size	se.Expected School Size	cv.Expected School Size
a	1.59	0.157	0.099
b	1.00	0.000	0.000
c	1.20	0.224	0.186
d	1.00	0.000	0.000
e	1.00	0.000	0.000
f	1.49	0.156	0.105

Table 7. Abundance estimate.

Block	Abundance	se	cv	95%LCI	95%UCI
a	2,015	1,569.9	0.779	427	9,519
b	6,861	5,859.5	0.854	1,544	30,492
c	2,121	1,624.7	0.766	526	8,559
d	435	318.2	0.731	109	1,744
e	1,862	991.2	0.532	685	5,056
f	2,327	1,499.7	0.645	660	8,206
Total	15,621	6,539.9	0.419	7,106	34,340

Table 8. Comparison of abundance estimates in sub-area 12NE.

Year	Month	Mode*	Areal coverage (%)	Abundance	CV	Source
1989-1990	Aug-Sep	NCL	100.0	10,397	0.364	JCRM 6:124
1999	Aug-Sep	NCL	89.4	11,544	0.380	JCRM 6:124
2003	Aug-Sep	IOP	46.0	13,067**	0.287	SC/61/RMP11
2015-2020	Aug-Sep	NCL	89.0	15,621	0.419	this study

* :NCL;Normal closing mode, IOP; Independent Observer Passing mode

**:g(0) corrected

Appendix 1

Examples of perpendicular distance distribution of the past minke whale sighting surveys

1. 1989-90 surveys (binocular used for observation)

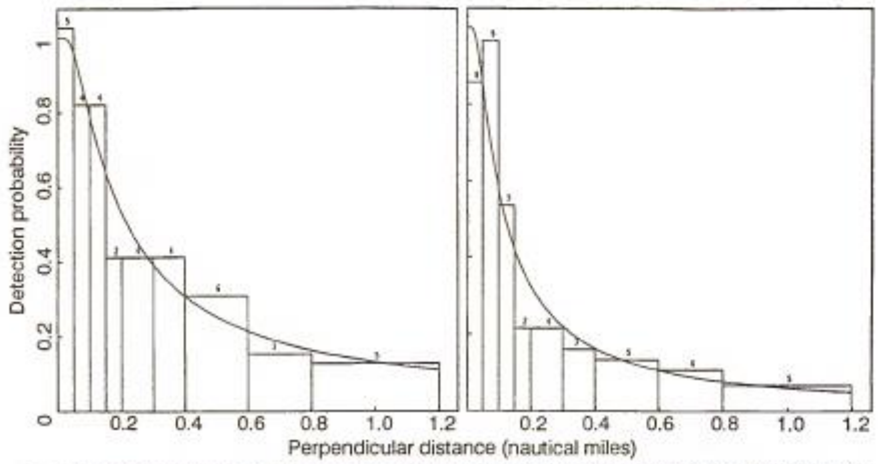

Fig. 3. Fits of the hazard-rate model to smeared perpendicular distance data recorded during Beauforts 0–2 (left) and 3–4 (right), pooled over all cruises and over both years, 1989/90.

Reference: Buckland, S.T, Cattanach, K.L and Miyashita, T. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. *Rep. int. Whal. Commn* 42: 387-392.

2. 2003 survey (naked eyes used for observation)

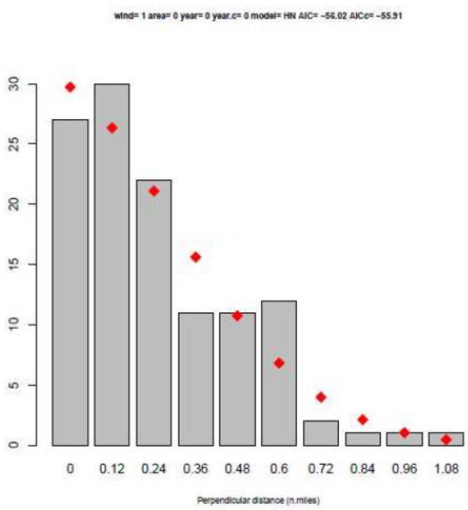

Fig. 47. Perpendicular distance distribution and the fitness of detection curve for the abundance estimate using top-barrel and the upper bridge sighting during the IO mode surveys in the Sea of Okhotsk and the Russian 200 n.miles EEZ east of the Kuril archipelago and the Kamchatka peninsula.

Square shows the values of the best fit (Half normal model) to the observed values (bars).

Reference: Miyashita, T. and Okamura, H. 2011. Abundance estimates of common minke whales using the Japanese dedicated sighting survey data for RMP Implementation and CLA – Sea of Japan and Sea of Okhotsk. SC/63/RMP11. 33pp.

3. 2006 survey (naked eyes used for observation)

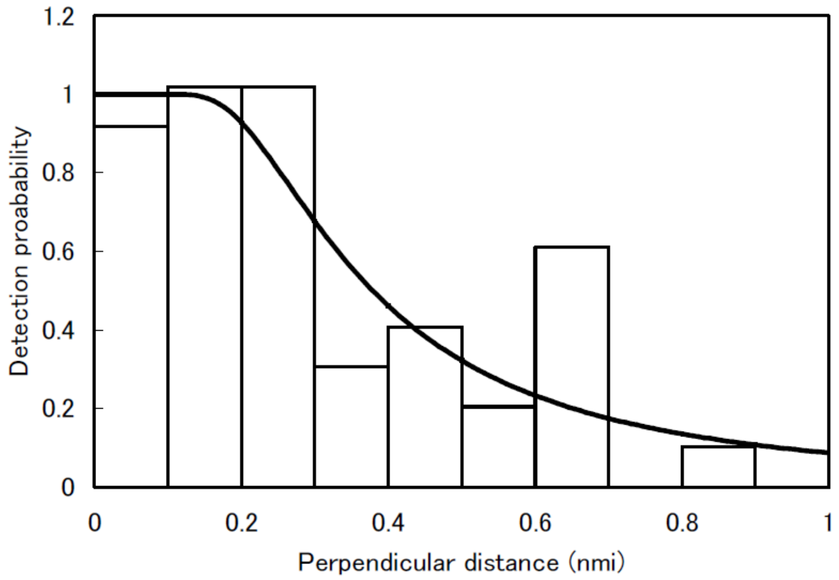

Fig. 4. Hazard rate curve applied to the perpendicular distance distribution in the conventional line transect method.

Reference: Miyashita, T. and Okamura, H. 2004. Abundance estimate of common minke whales in the northern Sea of Japan including the Russian EEZ using IO sighting data in 2006. SC/59/NPM4.

Appendix 2

Information on the past sighting surveys in the Sea of Okhotsk to consider additional variance

Because of the presence of the restricted area and the un-surveyed area for a long time, the situation around the sighting surveys in the Sea of Okhotsk was different from the those in the Antarctic (Antarctic minke whale), the North Atlantic (common minke whale) and the western North Pacific (Bryde's whale) which have considered additional variance. This appendix shows available information on the past sighting surveys in the Sea of Okhotsk which were used for abundance estimate in the past.

The past abundance estimates were obtained from the three sighting surveys, namely, in 1989-90, in 1999 and in 2003. Then the past results were tabulated and compared by current 2015-2020 block.

1 . Block definition

When the surveys were conducted in 1989 and 1990, there was no restricted and no block was set. Since mid-1990's, the Russian Federation restricted the Japanese vessels to enter the northeastern coastal waters, and considering the past information on the common minke whale sightings, the blocks were set up to carry out the survey efficiently.

Fig. 4 on the main text shows the present blocks in the sub-aera 12NE for the 2015-2020 surveys. There are seven blocks taking into account of the yearly coverage by the limited research period (around 35 days per year). Blocks b, c and d fall under the most resent restricted area for the Japanese vessel.

Figs. 1 to 3 show the historical change of blocks comparing with that of 2015-2020 block. In 1989 and 1990, no blocks and the whole area in the Sea of Okhotsk was considered as one block (Fig. 1). The surveys in 1989 and 1990 were conducted by one vessel each year. In 1999, the research area was south of 58°N and west of 155°E, and three blocks were set up (Fig. 2). One vessel conducted the sighting survey in 1999. In 2003, because two vessels were available and it was the first time to conduct the full-scale IO mode survey in this area, nine blocks were set up (Fig. 3). The blocks set up in 1999 and 2003 were different figures each other and also different from those in 2015-2020.

Of course, the un-surveyed area was remained in the northeastern area in 1999 and 2003, but in these two seasons, the southeastern block g was covered partially. The 2015-2020 surveys have never cover block g, but it will be covered in the future.

2. Comparison of track line

To keep the uniform coverage probability in block, resent surveys has been used the program DISTANCE (Thomas *et al.*, 2010) to get the pre-determined track line. For the surveys other than 2015-2020, because there was no such useful program, the track line was set up by hand to keep the uniform coverage probability as much as possible. In 1989, because it was the first time to conduct sighting survey in the Russian 200 n.miles EEZ, the survey was more preliminary in nature and the track line was set up to cover the whole area as much as possible during the limited short period (Fig. 4). In 1990, the research period became longer than the former season, the track line was based on parallel lines, aiming to be as perpendicular to the coast as possible (Fig. 5). In 1999, the track line was designed based on zigzag lines, and the eastern half of the northern block was not covered by the bad weather (Fig. 6). In 2003, the track line was set up also based on zigzag lines (Fig. 7). In this season, the vessel to cover the eastern blocks could not obtained enough time to cover due to a personal injury and bad weather. Comparing with the past surveys, the track line traversed on sighting effort and sighting positions during 2015-2020 seasons have been shown in Fig. 5 on the main text.

3. Research distance and sighting results

Ignoring discrepancies between the shape of the block and the design of each track line, the research distance and the number of primary sightings were tabulated in the blocks used for 2015-2020 surveys (Table 1). A total of six blocks and year combinations had research distances but zero primary sightings.

4. Consideration for additional variance

Until now, it was only in 1989 and 1990 that the entire sub-area 12NE could be surveyed in one year. Then the additional variance can be estimated by comparing the results in 1989-1990, but since nearly

30 years have passed since 1989-1990, some assumptions need to be made to make an estimate. For other seasons, in 1999 and in 2003, because the un-surveyed area was remained in the north eastern coastal waters, there was a possibility that some animals moved into or moved out the un-surveyed area but no information. Therefore, some assumptions are also necessary to estimate additional variance in these cases. Third point to be considered is that the block design and the track line design were changed between seasons. If the block design is constant, comparing is possible to estimate additional variance, but not case, how to treat needs further consideration. Considering those points, it is difficult to estimate additional variance in the case of the Okhotsk Sea at this stage and needs sufficient surveys.

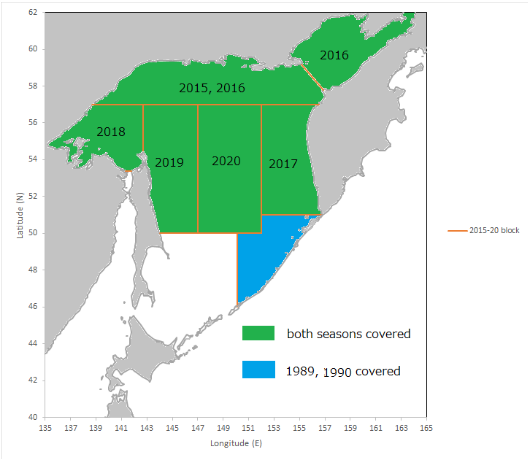

Fig. 1. Coverage in 12NE. 1989 and 1990 surveys VS 2015-2020 surveys.

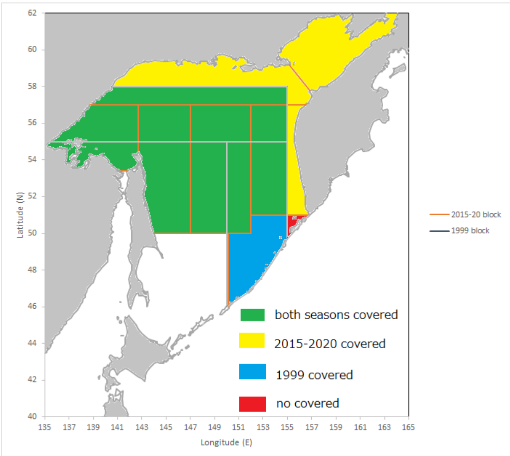

Fig. 2. Blocks and coverage. 1999 survey VS 2015-2020 surveys.

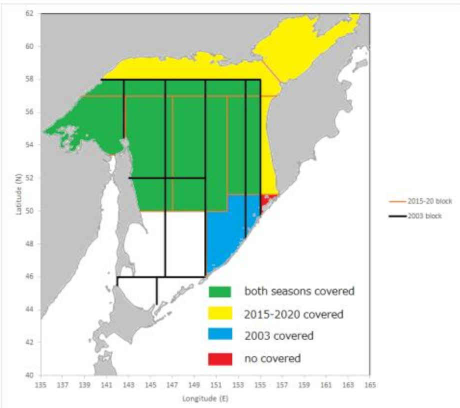

Fig. 3. Blocks and coverage. 2003 survey VS 2015-2020 surveys.

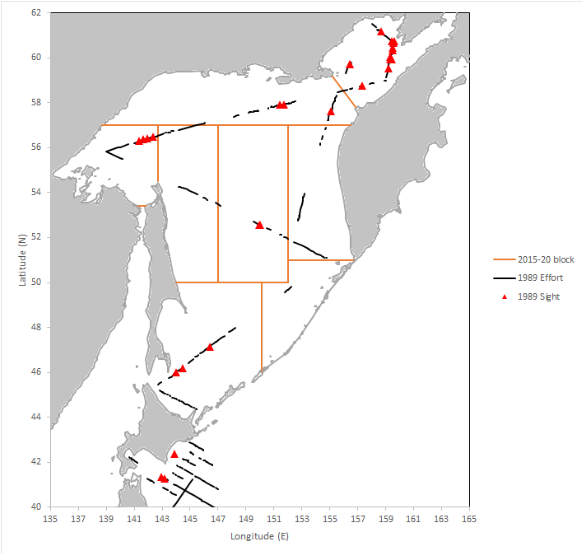

Fig. 4. Track line traversed on effort and sighting positions of primary sightings in 1989. Blocks in 12NE are for the 2015-2020 seasons.

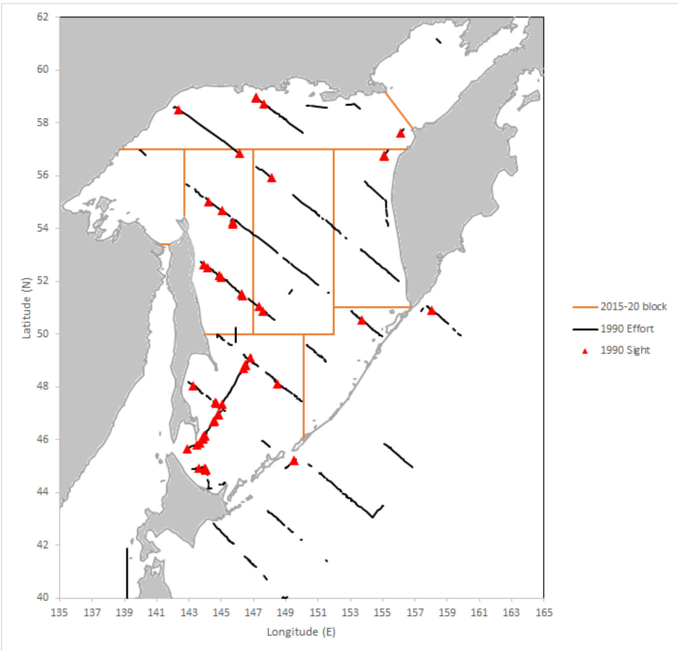

Fig. 5. Track line traversed on effort and sighting positions of primary sightings in 1990. Blocks in 12NE are for the 2015-2020 seasons.

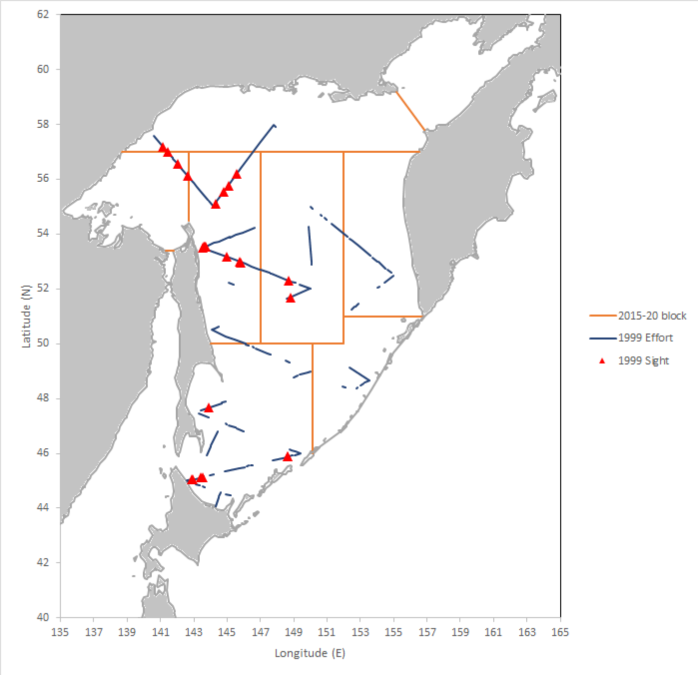

Fig. 6. Track line traversed on effort and sighting positions of primary sightings in 1999. Blocks in 12NE are for the 2015-2020 seasons.

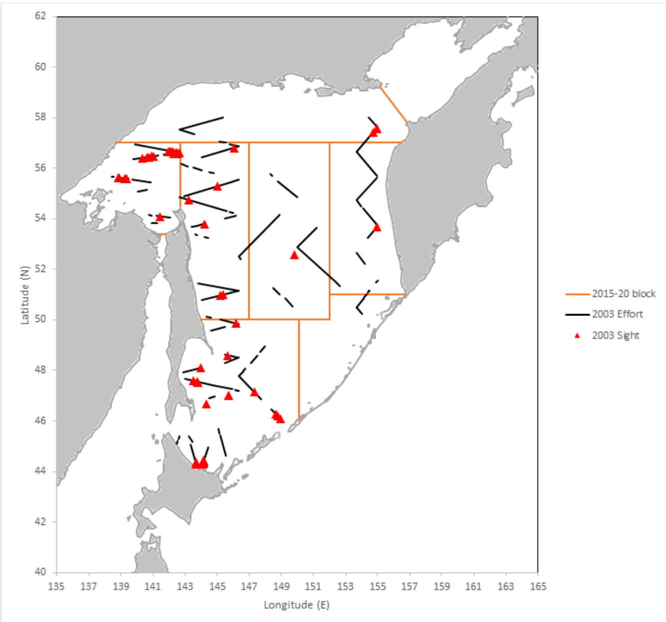

Fig. 7. Track line traversed on effort and sighting positions of primary sightings in 2003. Blocks in 12NE are for the 2015-2020 seasons.

Table 1. Research distance (n.miles)(L) and numbre of primary sightings (n) by blocks used for 2015-2020 season.

Block	1989		1990		1999		2003		2015-2020	
	L	n	L	n	L	n	L	n	L	n
a	124.9	2	401.1	3	353.3	2	407.3	1	1,223.1	11
b	151.2	7	336.9	4	129.2	1	209.5	3	1,034.5	6
c	206.6	9	32.5	1	-	-	-	-	669.2	3
d	116.5	0	217.5	2	104.9	0	321.3	1	885.7	2
e	155.0	4	23.4	0	83.2	3	418.3	29	1,258.7	14
f	122.5	0	340.0	12	573.3	13	627.6	6	1,188.4	9
g	24.8	0	90.9	1	90.9	0	59.8	0	-	-
Total	901.5	22	1,442.3	23	1,334.9	19	2,043.7	40	6,259.7	45

ANNEX 2

Abundance estimates of common minke whales in sub-areas around Japan based on dedicated sighting surveys conducted during 2018-2020

TAKASHI HAKAMADA, MEGUMI TAKAHASHI AND KOJI MATSUOKA

INSTITUTE OF CETACEAN RESEARCH, 4-5 TOYOMI-CHO, CHUO-KU, TOKYO104-0055, JAPAN

ABSTRACT

This paper provides abundance estimates for western North Pacific common minke whales (*Balaenoptera acutorostrata*) in management sub-areas around Japan based on dedicated sighting surveys conducted in spring (May-June) 2018 and 2019 and summer (July-September) 2020. Abundances were estimated by the standard distance sampling methodology and the guidelines adopted by the International Whaling Commission Scientific Committee under the assumption of g(0)=1. In the Sea of Japan, abundance estimates in sub-areas 10E and 6E were 805 (CV=0.502) in spring 2018 and 2,389 (CV=0.392) in spring 2019. In the southern part of the Okhotsk Sea (sub-area 11), abundance estimate was 306 (CV=0.505) in spring 2018. In the Pacific side, abundance estimates in sub-areas 7CN and 7CS were 103 (CV=0.739) and 159 (CV=0.766), respectively, in spring 2018. Abundance estimate in sub-area 7WR was 77 (CV=1.017) in spring 2019. Abundance estimates in sub-areas 7CN and 9 were 219 (CV=0.671) and 642 (CV=0.703), respectively, in summer 2020. Abundance estimates in this study can be used to model distribution of this species for the objectives of *Implementation Simulation Trials*. Only abundance estimates in summer 2020 contribute to the estimation of total stock size by summing the abundance of different sub-areas (mainly sub-area 12NE) in that season.

INTRODUCTION

Previously, abundance estimate of common minke whales in the offshore sub-areas of the western North Pacific were estimated using dedicated sighting survey data obtained during JARPNII (Hakamada *et al*., 2009; Hakamada and Matsuoka 2016). These surveys were designed mainly considering the 22 sub-areas used by the International Whaling Commission Scientific Committee (IWC SC) for the management of North Pacific common minke whales in the past (Figure 1).

More recently, Japanese dedicated sighting surveys were conducted in coastal waters around Japan from May to June (spring) in 2018 and 2019 (Matsuoka *et al*., 2019; Katsumata *et al*., 2020), and in more offshore waters of the western North Pacific from July to September (summer) in 2020 (Katsumata *et al*., 2021). In 2018 and 2019, the surveys were conducted to estimate the abundance of the J and O stocks common minke whales in coastal waters of Japan. In addition, an IWC-Pacific Ocean Whale and Ecosystem Research (POWER) survey was conducted in offshore areas in summer 2020 (Murase *et al*. 2021). Survey blocks in the 2020 summer surveys were not the same as the sub-areas because other large whales than the common minke whales were included as the target species.

Because coastal waters around Japan and offshore area of Japan in western North Pacific are migratory corridor of the common minke whale (Hatanaka and Miyashita, 1997), abundance estimate for this species by sub-areas could be different among the survey months. Abundance estimates in spring can be used to model distribution of this species in spring, and abundance estimates in summer can be used to estimate stock size of this species by summing abundance estimate of different sub-areas including those in the Okhotsk Sea based on surveys conducted in summer.

Abundance by sub-areas for the common minke whales were estimated by standard distance sampling methodology (Thomas *et al*., 2010) following the guidelines adopted by the IWC SC under the assumption of *g*(0)=1, based on the sighting data collected in the 2018-2020 surveys in different seasons.

MATERIALS AND METHODS

Sighting surveys

The sighting surveys in 2018, 2019 and 2020 were conducted with IWC oversight. Survey blocks and survey periods for these surveys are shown in Table 1. Survey sub-areas for the Japanese dedicated sighting surveys conducted from May to June in 2018 and 2019 are shown in Figure 2a. Survey blocks for the Japanese dedicated sighting survey and the IWC-POWER survey conducted from July to September in 2020 are shown in Figure 2b. Blocks I, II and III were surveyed in the Japanese survey and block IV was surveyed in the IWC-POWER survey.

Sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 are also shown in Figure 2b for comparison with the blocks. Sub-areas 7CS, 7CN, 7WR and 7E comprise block I. Sub-area 8 comprise the western part of block II (west of 157°E) and western part of block III (west of 157°E). Sub-area 9 comprises the eastern part of block II (east of 157°E), eastern part of block III (east of 157°E) and block IV.

Plot of searching effort and primary sightings for the surveys in 2018 and 2019 (spring) are shown in Figure 3a while Figure 3b shows the searching effort and primary sightings for the surveys in 2020 (summer). Survey design and analytical procedures followed the IWC guidelines (IWC, 2012).

Analytical Procedure

It was assumed that $g(0)=1$. Truncation distance was at 1.5 n.miles (i.e., detections whose perpendicular distance is more than 1.5 were truncated in this analysis). The truncated distance was chosen for consistency with previous analyses for this species (Hakamada and Kitakado, 2011; Hakamada and Matsuoka, 2016; Hakamada *et al*, 2019). Observed angles and distances were corrected if significant biases were detected during the distance and angle experiments conducted during the surveys using the method in Branch and Butterworth (2001). Abundance and its variance were estimated based on a Horvitz-Thompson like estimator of abundance expressed by equations (1) and (2), respectively.

$$P = \frac{A}{2WL}\sum_{i=1}^{n}\frac{s_i}{p_i(z_i)}$$

$$= \frac{A}{2L}\sum_{i=1}^{n} s_i\hat{f}(0|\boldsymbol{z}_i) \qquad (1)$$

where P is the abundance estimate, A is the area size of the survey stratum (i.e., block/sub-area), W is truncation distance (1.5 n.miles for the common minke whales) L is searching effort, n is the number of schools detected within perpendicular distance W, s_i is the school size of the ith detection, $p_i(z_i)$ is the probability that school i is detected given that it is within the perpendicular distance W and given the covariate z_i. $f(0|z_i)$ is the conditional probability density function of distance 0 given covariates z_i, such as school size and Beaufort sea state which were used here.

The variance of the estimate is given by Eq. (2) below:

$$var(P) = \left(\frac{A}{2WL}\right)^2\left\{\frac{1}{L(K-1)}\sum_{k=1}^{K} l_k\left(\frac{P_{Ck}}{l_k}-\frac{P_C}{L}\right)^2 + \sum_{j=1}^{r}\sum_{m=1}^{r}\frac{\partial P_C}{\partial\theta_j}\frac{\partial P_C}{\partial\theta_m}H_{jm}^{-1}(\theta)\right\} \quad (2)$$

where K is the number of transect, l_k is searching distance in kth transect, P_{Ck} is abundance estimate in the covered region (within W n.miles from track line surveyed) in kth transect, P_C is abundance estimate in the covered region, $H_{jm}^{-1}(\theta)$ is the jmth element of inverse of Hessian matrix of detection function for vector of coefficients θ.

Using Horvitz-Thompson like estimator, expected mean school size were estimated by the following equation:

$$\frac{\sum_{i=1}^{n}\frac{s_i}{p_i(z_i)}}{\sum_{i=1}^{n}\frac{1}{p_i(z_i)}} \quad (3)$$

Multiple Covariate Distance Sampling (MCDS) Engine in DISTANCE program was used (Thomas *et al.*, 2010). Hazard rate (Equation (4)) and Half normal (Equation (5)) models were considered as candidate models for the detection function:

$$g(x) = 1 - \exp\left[-\left\{{}^{x}\!/_{a\exp(Size + Beaufort)}\right\}^{-b}\right] \quad (4)$$

$$g(x) = \exp\left[-{}^{x^2}\!/_{2a^2\exp\{2(Size + Beaufort)\}}\right] \quad (5)$$

where x is the perpendicular distance, a and b ($b \geqq 1$) are parameters, *Size* is the observed school size and *Beaufort* is the categorical variable for Beaufort sea state (good: 0-2, bad: 3-5). AIC was used to select the best model to estimate detection probability.

A quantile–quantile (QQ) plot was used to determine whether the empirical cumulative distribution function (cdf) and fitted cdf are similar distributions, indicating a good fit (Burnham *et al.*, 2004).

Abundance for common minke whales by sub-areas/blocks and their variances were estimated by applying formulas (1) and (2), respectively.

Derivation of the abundance estimate by sub-areas in 2020

For the spring surveys in 2018 and 2019, survey blocks corresponded to the sub-areas and therefore abundance estimate correspond to the sub-areas in those surveys. Because the survey blocks in 2020 were different from the sub-areas, abundances were estimated by blocks I, II, III and IV first. Then, abundance estimate by sub-areas were derived. Sighting data in block I were divided into the data for sub-areas 7CS, 7CN, 7WR and 7E.

Equations (1) and (2) were applied to the divided sighting and effort data by sub-area to estimate encounter rate and abundance in sub-areas 7CS, 7CN, 7WR and 7E, respectively. This method is same as that used for abundance estimate for those sub-areas in the period 2002-2009 (Hakamada and Kitakado, 2011). The primary sightings of the common minke whales occurred in sub-area 7CN (Figure 3c). There was no primary sighting in sub-areas 7CS, 7WR and 7E.

In order to estimate abundance in sub-areas 8 and 9, blocks II and III were divided by the boundary of sub-areas 8 and 9. Given that the coverage probability could be different among the blocks, abundance estimate for each part of the blocks were totaled. Such approach was used to estimate abundance for North Pacific Bryde's whales by sub-areas using IWC-POWER and JARPNII survey data (Hakamada *et al.*, 2017).

Regarding sub-area 8, there was no primary sighting of the common minke whales in the western part of block II and in western part of block III (Figure 3b). For parts of the blocks in sub-area 9, there were some primary sightings of the minke whales only in the block IV and there was no primary sighting of the common minke whales in the eastern part of the block II and in the eastern part of the block III (Figure 3b).

RESULTS AND DISCUSSION

Table 2 shows AIC for each model of the detection functions. The best model was Hazard rate model (i.e., Equation (4)) with no covariates. A plot of the best detection model compared to relative frequency of the detection is shown in Figure 4. Averaged effective search width (ESW) was 0.412 (CV=0.202). QQ plot seemed that point is close to 1:1 line in the plot. This suggested that the model fits to the relative frequency data well.

Expected mean school sizes by survey blocks derived by equation (3) are shown in Table 3. The expected mean school size was 1 or close to 1 in all survey blocks where the common minke whale were sighted, same as in previous analyses (Hakamada *et al*., 2009; Hakamada and Matsuoka 2016).

The abundance estimates by survey blocks for spring 2018-2019 are listed in Table 4. Abundance estimates for sub-areas 7CN, 7CS, 10E and 11 were 103 (CV=0.739), 159 (CV=0.766), 805 (CV=0.502) and 306 (CV=0.505), respectively, in 2018. Abundance estimates in sub-areas 6E and 7WR were 2,389 (CV=0.392) and 77 (CV=1.017), respectively, in 2019.

Abundance estimates by survey blocks in summer 2020 are shown in Table 5. Abundance estimates in block I and block IV were 227 (CV=0.738) and 642 (CV=0.703), respectively. Table 6 shows the estimated number in sub-areas 7CS, 7CN, 7WR and 7E after post-stratification. Abundance estimate was 219 (CV=0.671) in sub-area 7CN.

Effort per unit area size (*L*/*A*) for sub-areas 7, 7CS, 7CN, 7WR and 7E were 0.011, 0.008, 0.011, 0.012 and 0.010, respectively. This implies that the coverage probability in sub-area 7 was similar to those in sub-areas 7CS, 7CN, 7WR and 7E. Abundance estimates in the western part of block II and that in the western part of block III were 0 and therefore abundance estimate in sub-area 8 was 0. Abundance estimate in block IV was 642 (CV=0.703) and abundance estimate in other parts of sub-area 9 were 0. Therefore, abundance estimate for sub-area 9 was 642 (CV=0.703). Table 7 shows resultant abundance estimates by sub-areas obtained from the sighting surveys during 2018-2020.

Abundance estimates for sub-area 9 in summer 2020, which will be used for catch limit calculation, were compared with previous estimates (Table 8). The ESW estimate of 0.420 is in the range of ESW estimates in previous analyses. In 1990, the survey was conducted north of 40°N including Russian EEZ whereas Russian EEZ was not surveyed in other years. This is probably the reason why the abundance estimate in 1990 is the highest among the estimates listed in Table 8. Abundance estimate in 2020 is lower than the previous ones. A possible explanation is that in 2020 warm waters (20°C or more) were spread in the blocks I, II and III (Katsumata *et al.*, 2021) whereas sea surface temperature at the sighting positions of the common minke whales in that year ranged from 10.4°C to 14.9°C (Katsumata *et al*., 2021; Murase *et al*., 2021). This is a possible reason why less primary sightings of the common minke whales occurred in the survey area in 2020 than usual.

Regarding the detection function, the ESW was common for all survey blocks as a result that the best model was hazard-rate model with no covariate. Kruskal-Wallis test (e.g. Dalgaard, 2002) was conducted to test the null hypothesis that distribution of perpendicular distance in each sub-area comes from one population distribution function. Chi-square statistics was 12.78 (df=7) and p-value was 0.07764. The null hypothesis was not rejected at 5% significant level. Therefore, it is not unreasonable to assume the same value across sub-areas and hence that this assumption is likely not introducing any dramatic bias in abundance estimates in space and time.

Regarding g(0) estimates, Independent Observer (IO) mode and normal passing mode with abeam closing were conducted alternately during the sighting surveys in 2018, 2019 and 2020. Unfortunately, sufficient primary sightings were not obtained during the IO mode in these surveys to estimate $g(0)$. After sufficient primary sightings of the common minke whales are obtained in future sighting surveys, estimation of $g(0)$ for this species will be possible.

In order to examine which g(0) estimate can be applied to abundance estimates in the present analyses, specification of the research vessels and sighting procedures in the sighting surveys during 2018-2020 were compared with those in previous sighting surveys (JARPNII). Specification of the vessels used during the 2018-2020 surveys (*YS1*, *YS2*, *YS3* and *KY7*) comparing with the vessels used JARPNII dedicated sighting surveys (same vessels except *KY7*) were provided in Table 9. Height of the top barrel and upper bridge for *KS2* and *KK1* were similar to the other vessels. Sighting protocols in 2018-2020 are similar to those in previous surveys under JARPNII. One difference in the survey protocols between surveys during 2018-2020 and the previous surveys is that IO mode was conducted in the former and not in the latter.

For this reason, instead of the g(0) of 0.798 (SE=0.134) of Okamura et al. (2010) for top barrel and upper bridge, which were applied to the previous abundance estimates, the *g*(0) estimate of 0.859 (SE=0.103) estimated by the same authors for top barrel, IO platform and upper bridge can be used for adjusting the abundance estimated in this paper. Because some of the primary sightings occurred in normal passing mode with abeam closing, abundance estimates adjusted by this g(0) (0.859) are considered to be underestimated. This approach is preferable from a conservation point of view.

ACKNOWLEDGEMENTS
The authors thank all researchers and crew involved with the dedicated sighting surveys during 2018-2020. The authors appreciate the comments offered by T. Kishiro and T. Miyashita (Fisheries Resources Institute, Japan Fisheries Research and Education Agency, in Japan) that improved the contents of this paper. Also we thank L.A. Pastene (Institute of Cetacean Research), D.S. Butterworth and L. Walløe for their valuable comments and suggestions to improve the manuscript.

REFERENCES
Branch, T.A. and Butterworth, D.S. 2001. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2): 143–74.

Burnham, K.P., Buckland, S.T., Laake, J.L., Borchers, D.L., Marques, T.A., Bishop, J.R.B. and Thomas, L. 2004. Further topics in distance sampling. In: Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. (eds) Advanced distance sampling. Oxford University Press, London, pp 307–392.

Dalgaard, P. 2002. Introductory statistics with R. Springer, New York, 267pp.

Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of the Okhotsk Sea-West Pacific stock of minke whales, estimates based on length composition data. *Rep. int. Whal. Commn*. 47: 557-564.

Hakamada, T. and Kitakado, T. 2011. Abundance estimation for the western North Pacific common minke whales based on sighting information from JARPN and JARPN II. Paper SC/63/RMP18 presented to IWC Scientific Committee. June 2011, (unpublished). 25pp. [Paper available at the IWC Office].

Hakamada, T. and Matsuoka. 2016. The number of western North Pacific common minke, Bryde's and sei whales distributed in JARPN II Offshore survey area. Paper SC/F16/JR12 presented to JARPN II review meeting, February 2016. (unpublished). 13pp. [Paper available at the IWC Office].

Hakamada, T., Matsuoka, K. and Miyashita, T. 2009. Distribution and the number of western North Pacific common minke, Bryde's, sei and sperm whales distributed in JARPN II Offshore component survey area. Paper SC/J09/JR15 presented to JARPN II review meeting, January 2009, (unpublished). 18pp. [Paper available at the IWC Office].

Hakamada, T., Takahashi, M., Matsuoka, K. and Miyashita, T. 2017. Abundance estimate for western North Pacific Bryde's whale by sub-areas based on IWC-POWER and JARPNII sighting surveys. Paper SC/67A/RMP04 presented to IWC Scientific Committee. June 2010, (unpublished). 18pp. [Paper available at the IWC Office].

Hakamada, T., Katsumata, T., Takahashi, M. and Matsuoka, K. 2019. Common minke whale abundance estimates based on dedicated sighting surveys during 2013-2018. Paper SC/68A/ASI14 rev1 presented to IWC Scientific Committee. April 2019, (unpublished). 9pp. [Paper available at the IWC Office].

International Whaling Commission. 2012. Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *J. Cetacean Res. Manage.* 13 (Suppl.):507-18.

International Whaling Commission. 2014. Report of the working group on the *Implementation Review* for western North Pacific common minke whales. The report of the Scientific Committee, Annex D1. *J. Cetacean Res. Manage.* 15 (Suppl.):112-88.

Katsumata, T., Yoshimura, I., Tsunekawa, M., Kawabe, S. and Matsuoka, K. 2020. Results of the Japanese dedicated cetacean sighting survey in the western North Pacific in 2019 and 2020. Paper SC/68B/ASI18 presented to IWC Scientific Committee. April 2018, (unpublished). 25pp. [Paper available at the IWC Office].

Katsumata, T., Yoshida, T., Isoda, T., Yamaguchi, F., Yamazaki, M., Takahashi, M., Murata, H. and Matsuoka, K. 2021. Results of the Japanese dedicated cetacean sighting survey in the western North Pacific in 2020 summer season. Paper SC/68C/ASI14 presented to IWC Scientific Committee. April 2021, (unpublished). 17pp. [Paper available at the IWC Office].

Matsuoka, K., Hakamada, T., Yoshimura, I., Katsumata, T., Kasai, H. and Miyashita, T. 2019. Results of

Japanese dedicated cetacean sighting survey in western North Pacific. Paper SC/68A/ASI03 presented to IWC Scientific Committee. April 2019, (unpublished). 11pp. [Paper available at the IWC Office].
Murase, H., Katsumata, T., Yoshimura, I., Fujii, S., Abe, N. and Matsuoka, K. 2021. Cruise report of the 2020 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Paper SC/68C/ASI05 presented to IWC Scientific Committee. April 2021, (unpublished). 37pp. [Paper available at the IWC Office].
Okamura, H., Miyashita, T and Kitakado, T. 2010. *g* (0) estimates for western North Pacific common minke whales. Paper SC/62/NPM9 presented to IWC Scientific Committee. June 2010, (unpublished). 7pp. [Paper available at the IWC Office].
Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., Bishop, J. R. B., Marques, T. A., and Burnham, K. P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14.

Table 1. Research period, research vessel, planned cruise track, searching distance and percentage of track line realized for each survey block during sighting surveys 2018-2020.

Year	Survey block	Vessel	Period	Planned cruise track (n.miles)	Searching effort (n.miles)	% of track realised
2018	7CN	*KY7*	12-22 May	724.3	648.3	89.5%
2018	7CS	*KY7*	22 May-5 Jun	691.4	616.0	89.1%
2018	11	*YS2*	13-22 May	592.3	502.8	84.9%
2018	10E	*YS2*	22 May-21 Jun	1,268.2	1,102.8	87.0%
2019	6E	*YS2*	13 May-14 Jun	2,021.1	1,891.7	93.6%
2019	7WR	*YS1*	13 May-4 Jun	1,177.2	1,146.6	97.4%
2019	7E	*YS3*	14 May-2 Jun	871.8	805.3	92.4%
2020	I	*KY7*	7 Aug- 11 Sep	1,976.8	1,775.0	89.8%
2020	II	*YS1*	4 Aug-19 Sep	1,960.8	1,569.6	80.0%
2020	III	*YS3*	6 Aug-4 Sep	1,981.2	1,895.6	95.7%
2020	IV	*YS2*	26 Aug-17 Sep	1,178.1	981.7	83.3%

Table 2. AIC for each model of the detection function. S is a covariate for school size and B is a covariate for Beaufort Sea state. Δ AIC is the difference in AIC from the best model.

Key	Covariate	AIC	Δ AIC
HN	No	2.583	1.551
HN	S	4.578	3.546
HN	B	4.185	3.153
HN	S+B	6.172	5.140
HR	No	1.032	0
HR	S	2.925	1.893
HR	B	3.023	1.991
HR	S+B	4.921	3.889

Table 3. Expected mean school size for each survey blocks where detections of the common minke were occurred.

Year	Survey block	E(s)	CV(E(s))
2018	7CN	1.00	0.000
2018	7CS	1.00	0.000
2018	10E	1.00	0.000
2018	11	1.06	0.062
2019	6E	1.08	0.083
2019	7WR	1.18	0.048
2020	I	1.00	0.000
2020	IV	1.00	0.000
Total		1.10	0.031

Table 4. Abundance estimate for the common minke whale assuming g(0)=1 by survey blocks for the best detection function model based on sighting survey data during 2018-2019 spring. A is area size of the surveyed stratum, L is searching effort, n_s is the number of schools detected, n_w is the number of whale detected, n_w/L is encounter rate, CV(n_w/L) is its CV, P is abundance estimate, CV(P) is its CV, 95%LL is lower limit of 95% confidence interval (CI) of P and 95%UL is upper limit of 95% CI of P.

Year	Survey block	Period	A	L	n_s	n_w	n_w/L*100	CV(n_w/L)	P	CV(P)	95%LL	95%UL
2018	7CN	12-22 May	18,281	648.3	3	3	0.005	0.711	**103**	0.739	26	403
2018	7CS	22 May-5 Jun	26,826	616.0	3	3	0.005	0.739	**159**	0.766	39	649
2018	10E	13-22 May	40,648	1,102.8	17	18	0.016	0.459	**805**	0.502	306	2,119
2018	11	22 May-21 Jun	9,749	502.8	12	13	0.026	0.463	**306**	0.505	115	813
2019	6E	13 May-14 Jun	93,145	1,891.7	34	40	0.021	0.336	**2,389**	0.392	1,125	5,077
2019	7WR	13 May-4 Jun	72,991	1,146.6	1	1	0.001	0.997	**77**	1.017	14	438
2019	7E	14 May-2 Jun	48,208	805.3	0	0	0.000	0.000	**0**	0.000	0	0

Table 5. Abundance estimates for the common minke whale assuming g(0)=1 by survey blocks for the best detection function model based on sighting survey data during 2020 summer. The notation is as for Table 4.

Year	Survey block	Period	A	L	n_s	n_w	n_w/L*100	CV(n_w/L)	P	CV(P)	95%LL	95%UL
2020	I	7 Aug- 11 Sep	166,306	1,775.0	2	2	0.001	0.710	**227**	0.738	59	869
2020	II	4 Aug-19 Sep	116,915	1,569.6	0	0	0.000	0.000	**0**	0.000	0	0
2020	III	6 Aug-4 Sep	285,291	1,895.6	0	0	0.000	0.000	**0**	0.000	0	0
2020	IV	26 Aug-17 Sep	259,818	981.7	2	2	0.002	0.673	**642**	0.703	171	2,406

Table 6. Abundance estimates for the common minke whale assuming g(0)=1 in sub-areas 7CS, 7CN, 7WR and 7E with post-stratification. Notation is same as for Table 4.

Year	Sub-area	Period	A	L	n_s	n_w	n_w/L*100	CV(n_w/L)	P	CV(P)	95%LL	95%UL
2020	7CS	12 Aug- 27 Aug	26,826	225.1	0	0	0.000	0.000	**0**	0.000	0	0
2020	7CN	7 Aug- 12 Aug	18,281	202.2	2	2	0.010	0.639	**219**	0.671	45	1,068
2020	7WR	9 Aug- 11 Sep	72,991	860.1	0	0	0.000	0.000	**0**	0.000	0	0
2020	7E	16 Aug- 7 Sep	48,208	487.7	0	0	0.000	0.000	**0**	0.000	0	0

Table 7. Abundance estimates for the common minke whales assuming g(0)=1 by sub-areas where the common minke whales were detected during the surveys.

Year	Sub-area	Period	***P***	CV(*P*)	95%LL	95%UL
2018	7CN	Spring	**103**	0.739	26	403
2018	7CS	Spring	**159**	0.766	39	649
2018	10E	Spring	**805**	0.502	306	2,119
2018	11	Spring	**306**	0.505	115	813
2019	6E	Spring	**2,389**	0.392	1,125	5,077
2019	7WR	Spring	**77**	1.017	14	438
2020	7CN	Summer	**219**	0.671	45	1,068
2020	9	Summer	**642**	0.703	171	2,406

Table 8. Abundance estimates for the common minke in sub-area 9 in summer 2020 in comparison with estimates in previous surveys.

Year	Sub-Area	Period	Abundance Estimate	CV	% Covg	ESW (n.m)	Note
1990	9	Aug-Sep	3,287	0.819	61.4	-	North of 40N, Inc. Russian EEZ.
2003	9	15 Jul-5 Sep	2,546	0.276	33.2	0.609	North of 43N. Ex. Russian EEZ
2008	9	4 Jul-13 Aug	2,458	0.664	86.9	0.298	Ex. Russian EEZ
2020	9	26 Aug-17 Sep	642	0.703	86.9	0.420	Ex. Russian EEZ, *Warm waters were spread.

, *: ‘Warm waters’ indicates waters whose sea surface temperature is higher (20°C or more) than the range of the sea surface temperature at sighting positions of the common minke whales (10.4°C to 14.9°C) in 2020.

Table 9. Specification of research vessels engaged in dedicated sighting surveys under JARPNII (2002-2017) (*KS2*, *KK1*, *YS1*, *YS3*) and sighting surveys used for abundance estimates in this study (2018-2020) (*YS1*, *YS2*, *YS3*, *KY7*). *KS2*, *KK1*, *YS1*, *YS2*, *YS3* and *KY7* are abbreviations for *Kyoshin-Maru No.2*, *Kaiko-Maru*, *Yushin-Maru*, *Yushin-Maru No.2*, *Yushin-Maru No.3*, *Kaiyo-Maru No.7*. Note that IO platforms of *KS2* and *KK1* were not used during the survey because they did not engage in the surveys in IO mode.

Vessel	*KS2*	*KK1*	*YS1*	*YS2*	*YS3*	*KY7*
Call sign	JFHR	JGDW	JLZS	JPPV	7JCH	JECL
Length overall[m]	68.18	61.9	69.61	69.61	69.61	60.02
Gross tonnage [GT]	372	860.25	724	747	742	649
Top barrel height [m]	17	19.5	19.5	19.5	19.5	17.5
IO platform height [m]	10.5	14.5	13.5	13.5	13.5	12.7
Upper bridge height [m]	8	9	11.5	11.5	11.5	9.6
Engine power [kW]	1544	1471	3900	3900	3900	1,544
Period of vessel engaged	2002-2008	2008-2009	2010-	2011-	2011-	2018-

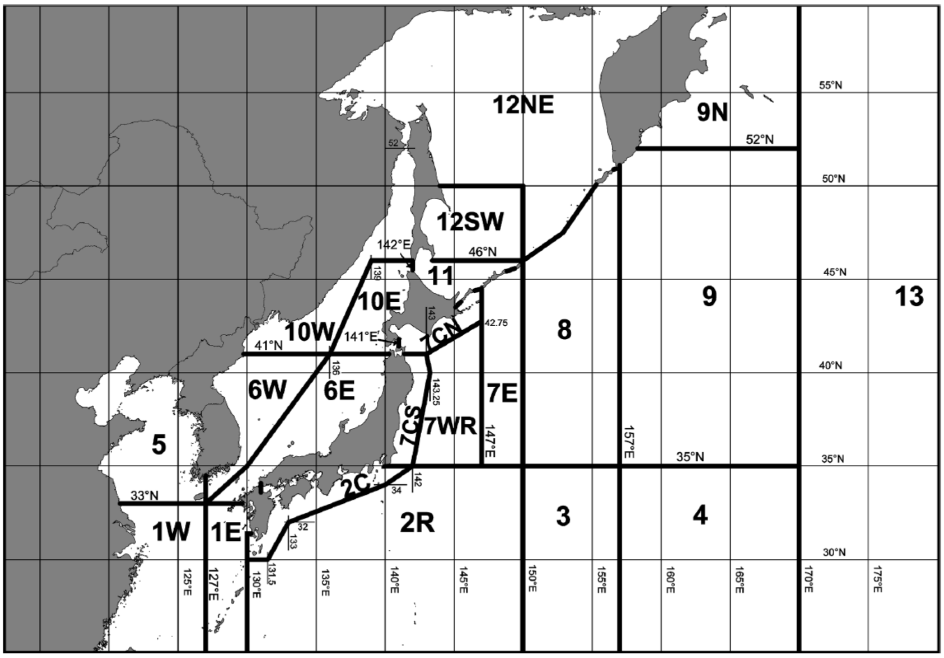

Figure 1. The 22 sub-areas used in the past by the IWC SC for the management of western North Pacific common minke whale (IWC, 2014).

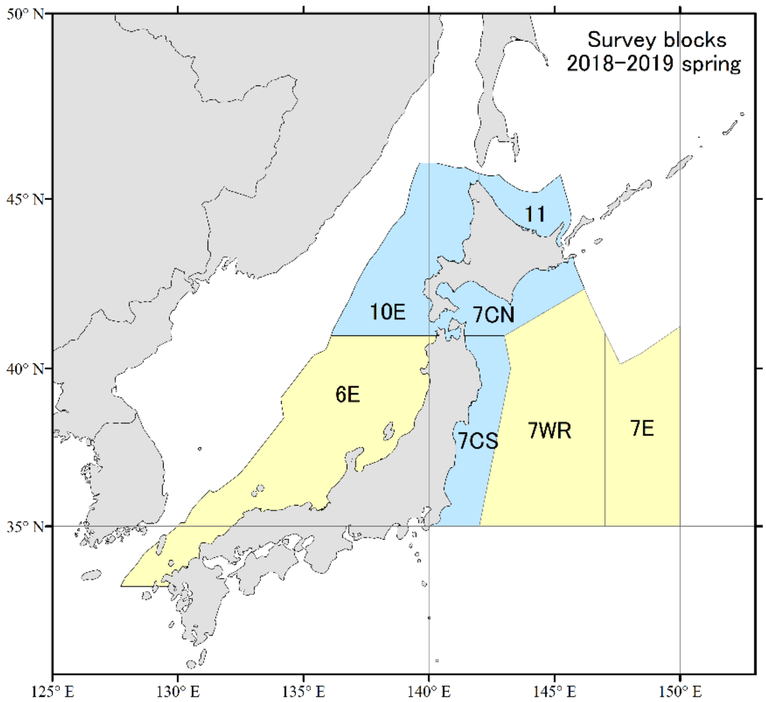

Figure 2a. Survey blocks for sighting surveys in 2018 and 2019 from May to June (spring). Light blue blocks were surveyed in 2018 and yellow ones were surveyed in 2019.

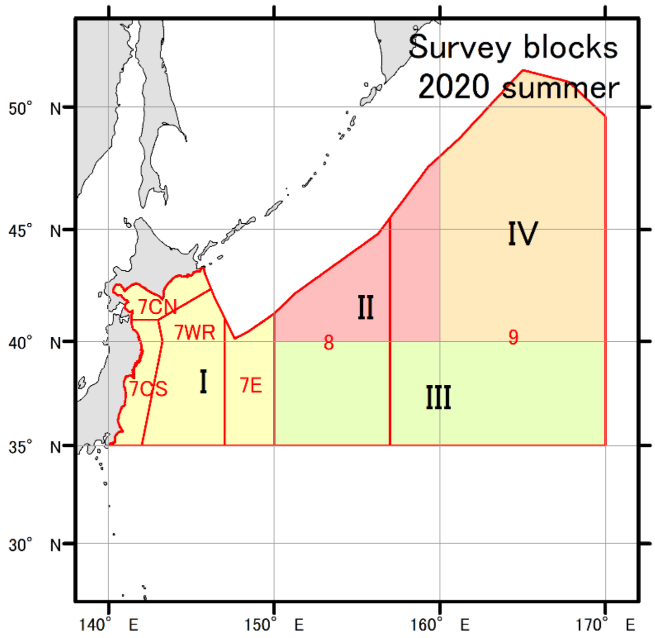

Figure 2b. Survey blocks I-IV for sighting surveys in 2020 from July to September (summer) and the sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 in Figure 1. Red lines indicate boundaries for the sub-areas and red letters indicate names of the sub-areas.

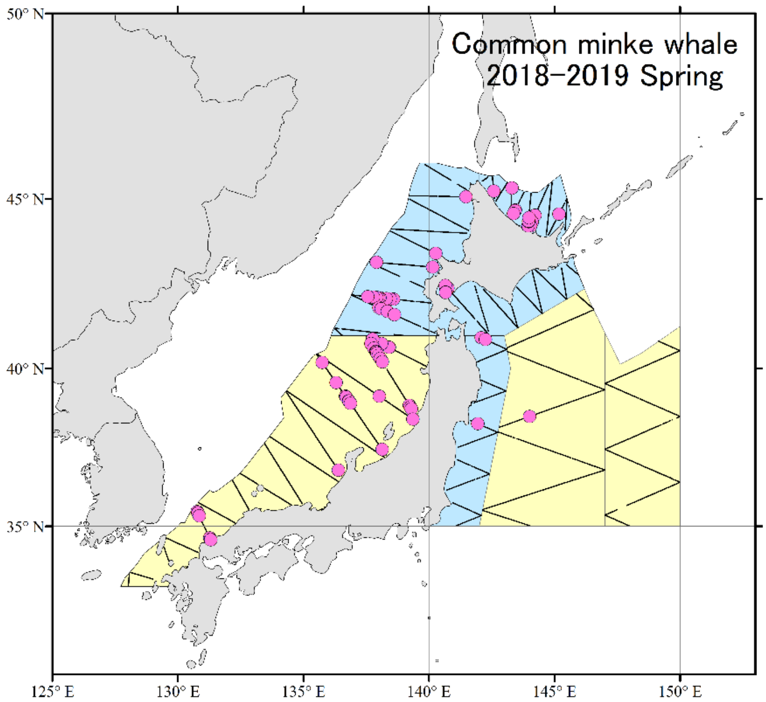

Figure 3a. Primary sighting positions of the common minke whales (pink circle) and searching effort during sighting survey conducted in 2018 and 2019 spring. Light blue blocks were surveyed in 2018 and yellow ones were surveyed in 2019.

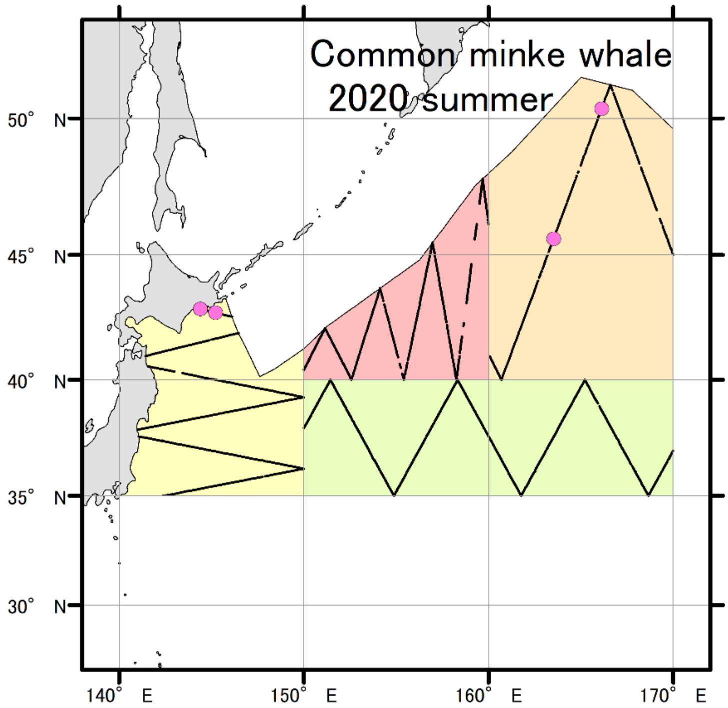

Figure 3b. Primary sighting positions of the common minke whales (pink circle) and searching effort during sighting survey conducted in 2020 summer.

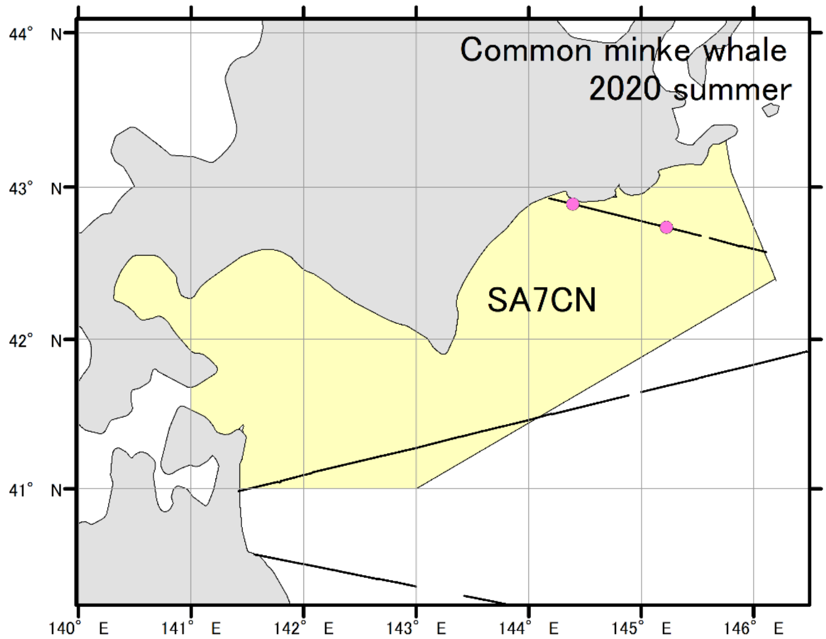

Figure 3c. Primary sighting positions of the common minke whales (pink circle) and searching effort during sighting survey in sub-area 7CN (yellow zone) conducted in 2020.

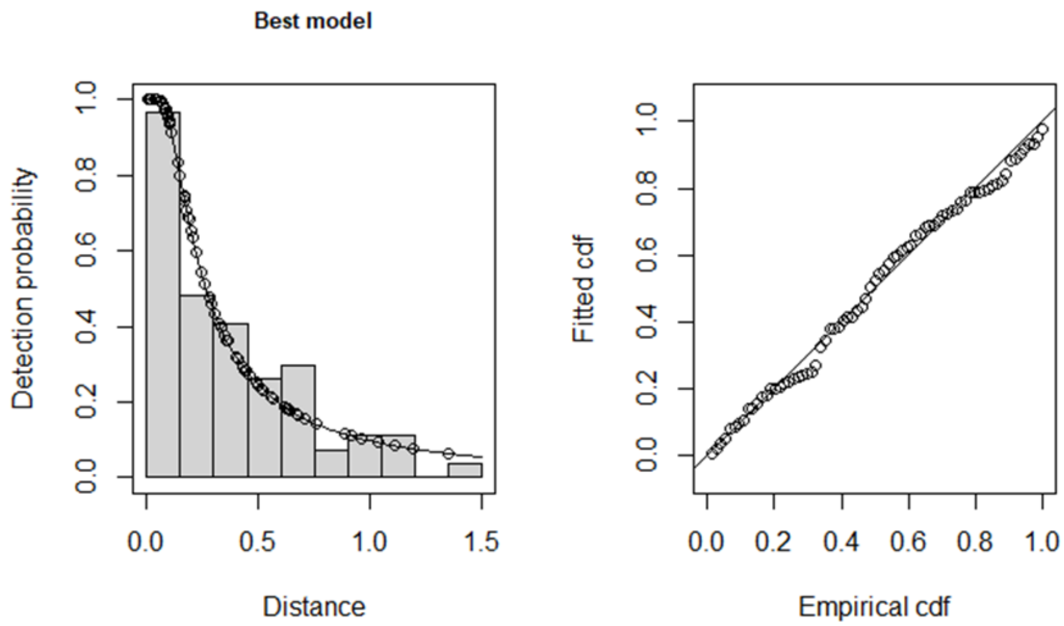

Figure 4. Plot of relative frequency of detection by perpendicular distance and the best detection function model (left panel) and Quantile-Quantile (QQ) plot for the model (right panel). The 'cdf' is abbreviation for cumulative distribution function.

ANNEX 3

Data used in the conditioning and *Implementation Simulations Trials* (*ISTs*) for North Pacific common minke whale

Megumi Takahashi and Takashi Hakamada

INSTITUTE OF CETACEAN RESEARCH, 4-5 TOYOMI-CHO, CHUO-KU, TOKYO104-0055, JAPAN

1. Abundance Estimates

Table 1 shows the abundance estimates by year and sub-area, which is based on the table agreed with in IWC SC 68c meeting. The estimates with annotations were new estimates by Japan or revised through communication with the IWC Secretariat and Japanese experts subsequently. The details for the new abundance estimates are available in Annexes 1 and 2 of these documents. All estimates, apart from the new estimates, were agreed by the IWC SC for use in the conditioning process (IWC, 2014).

Table 1 includes several estimates of zero abundance. The CVs in these cases were calculated in line with the procedure in IWC (2014).

Table 1. The abundance estimates used in conditioning the trials.

Year	Sub-area	Period	Estimate	CV	Note
2004	5	Apr-May	661	0.22	
2004	5	Apr-May	848	0.1	
2005	6W	Apr-May	456	0.144	
2005	6W	Apr-May	533	0.1	
2002	6E	May	891	0.608	
2003	6E	May-Jun	935	0.357	
2004	6E	May-Jun	727	0.372	
2019	6E	May-Jun	2389	0.392	New abundance estimate (see Annex 2)
2004	7CS	May	504	0.291	
2006	7CS	Jul	3690	1.199	
2012	7CS	May-Jun	537	0.346	
2020	7CS	Aug	0	1020	New abundance estimate (see Annex 2)
2016	7CS	Aug	0	1020	
2017	7CS	May	284	0.497	
2018	7CS	May-Jun	245	0.828	
1991	7W+7C	Aug-Sep	1164	0.183	
2012	7CN	May	542	0.601	
2017	7CN	May	179	0.377	
2018	7CN	May	103	0.739	
2012	7CN	Sep	599	0.525	
2014	7CN	Sep	244	0.454	
2016	7CN	Aug	185	0.423	
2020	7CN	Aug	219	0.671	New abundance estimate (see Annex 2)

Table 1. (Cont.)

Year	Sub-area	Period	Estimate	CV	Note
2003	7WR	May-Jun	157	0.7	
2004	7WR	May-Jun	863	0.648	
2013	7WR	May-Jun	65	1.007	
2006	7WR	Jun-Jul	0	239	
2007	7WR	Jun-Jul	546	0.953	
2009	7WR	Jun	215	0.942	
2012	7WR	Jun	378	0.79	
2008	7WR	Aug	0	239	
2016	7WR	Aug	75	1.062	
2019	7WR	May	77	1.017	New abundance estimate (see Annex 2)
2020	7WR	Aug-Sep	0	239	New abundance estimate (see Annex 2)
2004	7E	Jun	440	0.779	
2006	7E	May-Jun	247	0.892	
2007	7E	Jun-Jul	0	282	
2012	7E	Jun	0	282	
2013	7E	Jun	0	282	
2016	7E	Aug	0	282	
2019	7E	May	0	282	New abundance estimate (see Annex 2)
2020	7E	Aug-Sep	0	282	New abundance estimate (see Annex 2)
2005	8	May-Jul	132	1.047	
2006	8	May-Jul	309	0.677	
2004	8	Jun	1093	0.576	
2002	8	Jun-Jul	0	364	
2007	8	Jun-Jul	391	1.013	
1990	8	Aug	1057	0.706	
2008	8	Jul-Aug	0	364	
2009	8	May-Jun	602	0.725	
2013	8	May-Jun	413	0.586	
2011	8	May	121	0.966	
2020	8	Aug-Sep	0	364	New abundance estimate (see Annex 2)
2003	9	Jul-Aug	1843	0.276	
2008	9	Jul-Aug	2458	0.664	
1990	9	Aug	3287	0.819	
2009	9	May-Jun	2079	0.688	
2011	9	May	115	1.025	
2015	9	May	140	0.963	
2020	9	Aug-Sep	642	0.703	New abundance estimate (see Annex 2)
2005	9N	Aug-Sep	420	0.969	
2006	10W	May-Jun	2476	0.312	
2002	10E	May-Jun	1192	0.658	
2003	10E	May-Jun	591	0.566	
2005	10E	May-Jun	875	0.441	
2007	10E	Jun	672	0.327	Revised estimate
2014	10E	Sep	872	0.585	
2018	10E	May	805	0.502	
1990	11	Aug-Sep	2120	0.449	
1999	11	Aug-Sep	1456	0.565	
2003	11	Aug-Sep	882	0.826	
2007	11	Aug-Sep	230	0.389	
2014	11	Aug	306	0.679	
2018	11	May-Jun	306	0.505	
1990	12SW	Aug-Sep	4774	0.508	Revised estimate
2003	12SW	Aug-Sep	3401	0.409	
1990	12NE	Aug-Sep	11805	0.377	Revised estimate
1992	12NE	Aug-Sep	11051	0.705	Revised estimate
1999	12NE	Aug-Sep	5088	0.377	
2003	12NE	Aug-Sep	13067	0.287	
2018	12NE	Aug-Sep	15621	0.419	New abundance estimate (see Annex 1)

2. Stock Mixing Proportion Estimates

Table 2 lists the estimates of the proportion of recruited 'J' whales used to condition the trials, which were estimated in accordance with IWC (2021) for fitting the population trajectories for the stocks. Some of the mixing proportions are based on data from several years so the model estimates to which these proportions are fitted during conditioning are sample size-weighted year-specific proportions.

Table 2. The number of sampled whales that were assigned to each stock using the genetic assignment data based on STRUCTURE using a 90% probability of assignment. In sub-areas 7CS and 7CN, the proportion of whales assigned to each stock is weighted by 5/60 of the bycatch proportion and 55/60 of the special permit and commercial whaling proportion. The number assigned by stock is then taken as this proportion multiplied by the total number of assigned animals.

Area	Years	Months	Sex	Total Sample	Bycatch Samples		Scientific Permit & Commercial Whaling Samples		Weighted Total		Ratio (J:Total)
					J-Stock	O-Stock	J-Stock	O-Stock	J-Stock	O-Stock	
2C	2002-20	Jan-Apr	M+F	198					163	35	0.823
2C	2001-20	May-Sep	M+F	63					53	10	0.841
2C	2001-20	Oct-Dec	M+F	155					143	12	0.923
7CS	2002-20	Jan-Apr	M+F	341	78	39	56	168	97	244	0.284
7CS	2001-20	May	M+F	463	20	42	103	298	121	342	0.261
7CS	1999-2020	Jun-Dec	M+F	235	112	41	6	76	30	205	0.128
7CN	2002-20	Jan-May	M+F	134	31	33	12	58	26	108	0.194
7CN	1999-2020	Jun	M+F	158	15	20	11	112	19	139	0.120
7CN	1996-2020	Jul-Sep	M+F	717	23	13	129	552	163	554	0.227
7CN	2001-20	Oct-Dec	M+F	314	48	2	79	185	111	203	0.354
10E	2001-20	Jun-Dec	M+F	16					15	1	0.938
11	1996-2020	May-Dec	M	88					56	32	0.636
11	1996-2020	May-Dec	F	155					85	70	0.548

3. Catch Series

Two sources for non-natural mortality: direct catches and bycatches (which are also referred to as incidental catches) are used.

3.1. Direct catches

The catch series($t < 2021$) has been updated until 2020 through communication with the IWC Secretariat. Table 3a shows the summary of the western North Pacific minke whale direct catch series (1930-2020) by sex, year and sub-area. The baseline trials use the 'best' direct catch series (Table 3a), and an alternative 'high' catch series was used as a sensitivity trial (Trial 02) in order to examine the implications of uncertainty about historical catches.

Table 3b lists the 'high' catch numbers by years and sub-areas. The catches are identical to the 'best' series except for some few sub-areas and years. The Japanese coastal catches from 1930-31 and 1936-45 (in sub-areas 7CS, 7CN and 11) were summarized by Ohsumi (1982), and the values in the 'high' series are doubled for those periods (IWC, 2014). The catch series off Korea assumes a linear increase from 60 whales in 1946 to 249 in 1957 in the 'best' series whereas the 'high' series assumes an annual catch of 249 minke whales over this period.

Table 3a. Summary of the 'best' direct catch series for the western North Pacific minke whales by year, sub-area and sex.

Male

Year	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1930							7	0								1				8
1931							7	1								0				8
1932				0	9		13	1								0				23
1933				0	8		13	1						0		0				22
1934				1	21		20	1						0		0				43
1935				9	9		20	1								1				40
1936				12	14		15	0								0				41
1937				13	17		37	0								1				68
1938				15	20		44	0								1				80
1939				18	24		44	1					2			0			0	89
1940				15	33		52	0								1				101
1941				40	40		37	1					2			0				120
1942				53	67		44	0					1			1				166
1943				42	51		67	1								0				161
1944				38	47		52	0								1				138
1945				3	2		44	0								0				49
1946				11	21	14	51	4					1			4				106
1947				19	21	27	57	7								8				139
1948		3		22	26	56	57	1			1					26				192
1949				25	31	20	61				1		2		5	6		2		153
1950		3	0	29	37	15	63	41			2		1		13	18		0		222
1951	1	1		31	40	62	87	9		3	0		0		5	14		0		253
1952		1	0	36	45	142	92	1					1		9	20	0			347
1953				42	50	90	75	1			3				38	35	1			335
1954		0	1	43	54	35	24	26			0		0		32	59	1			275
1955				49	60	20	108	11			2				20	43	1	1		315
1956				54	62	16	140	25		1	3		0		47	69		0		417
1957	17	1		59	70	2	111	14	2		1				31	33	1			342
1958				67	65		126	13			1					86				358
1959				78	71		69	7								47		0		272
1960				72	59		64	6		1	1					41				244
1961				39	28		81	9			0					56				213
1962				55	52		46	7								48		0		208
1963				122	52		49	6								40				269
1964				139	95	6	85	6								39				370
1965		1		83	101	11	51	3								62				312
1966		2		76	87	0	81	8	1							71				326
1967				109	73	2	50	6							2	55				297
1968				98	75	8	58	4	1					2	0	22				268
1969				118	95	10	27	2					3		7	43				305
1970				186	188	5	101	5	1			2	4		8	38			2	540
1971				200	189	3	84	6							8	54	1			545
1972				252	286		35	17							0	78				668
1973				215	244	0	83	26		2	14				15	95	2	28		724
1974				213	271		63	34		9				1	5	44	4	22		666
1975				196	293	9	35	63		3				18	2	62	11	1		693
1976				353	174		35	27							10	89			0	688
1977				234	304		32	71							0	58				699
1978				181	354		93	133								19				780
1979				164	379		95	150							8	17				813
1980				447	147		88	72							10	40				804
1981		1		188	192		148	39	1						13	28				610
1982				229	210	2	105	56	1						9	5				617
1983				100	142	3	66	68							6	4				389
1984				87	105		64	88								46				390
1985			1	23	29	5	39	123							2	30				252
1986				1	31	20	69	89	0							19				229
1987							80	86								16				182
1988																				0
1989																				0
1990																				0
1991																				0
1992																				0
1993																				0
1994												18								18
1995												91								91
1996								28	0		16					19				63
1997									1	1	30	55								87
1998									22	26	41									89
1999							2	39	2							28				71
2000							4	15				16								35
2001							11	10	19	7	20	26								93

3a. (Cont.)

Male

Year	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
2002								79	1		8	31								119
2003							32		4	7	35	37								115
2004								62				75						1		138
2005							28	67	2		7	52								156
2006							41	33	11	1	36	23								145
2007							50	67	3		15	5								140
2008							23	33			5	48								109
2009							29	41	8	3	13	6								100
2010							17	40				12								69
2011							17	64				1								82
2012							47	61	4		3									115
2013							17	41				3								61
2014							16	35												51
2015							10	35												45
2016							7	8												15
2017							3	22	6	10	4	17				9				71
2018							28	22	4	1	15	14				16				100
2019							26	32	3							5				66
2020							1	58								4				63

Female

Year	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1930							4	0								1				5
1931							4	0								2				6
1932				5	4		7	0								1				17
1933				5	4		7	1						1		1				19
1934				9	10		10	0						1		1				31
1935				8	14		10	0								1				33
1936				12	13		7	0								2				34
1937				14	18		18	1								1				52
1938				18	20		22	0								1				61
1939				19	23		22	0					1			2			1	68
1940				13	34		25	0								1				73
1941				64	38		18	0					0			2				122
1942				54	66		22	0					2			1				145
1943				39	51		32	0								2				124
1944				38	45		25	0								1				109
1945				2	3		22	1								2				30
1946				10	18	10	24	1					1			13				77
1947				18	19	21	27	3								23				111
1948		0		21	25	38	31	0			0					53				168
1949				25	31	30	32				2		0		4	27		1		152
1950		1	1	29	34	9	25	19			0		0		0	32		1		151
1951	0	0		33	42	39	42	2		2	1		2		2	70		1		236
1952		0	1	37	45	43	78	2					1		0	97	1			305
1953				39	49	47	56	2			3				5	57	1			259
1954		1	0	45	55	27	22	15			3		1		4	124	0			297
1955				58	59	15	80	4			3				7	119	0	2		347
1956				62	66	23	97	7		0	1		1		13	108		4		382
1957	11	1		79	68	0	81	12	2		3				13	96	1			367
1958				101	63		128	8			1					153				454
1959				126	73		70	4								83		1		357
1960				141	57		65	4		1	1					73				342
1961				82	30		83	5			1					98				299
1962				117	52		47	5								85		1		307
1963				168	52		50	4								71				345
1964				186	97	6	86	4								69				448
1965		1		110	102	9	99	3								94				418
1966		1		105	88	2	100	15	0							84				395
1967				139	73	8	65	7							3	87				382
1968				124	73	3	81	3	0					7	5	56				352
1969				156	96	10	32	1					8		5	97				405
1970				216	188	2	87	5	1			0	0		4	70			2	575
1971				250	190	2	67	4							9	52	0			574
1972				292	286		75	22							1	113				789
1973				239	244	2	90	15		2	7				6	116	11	27		759
1974				267	272		51	19		3				0	3	79	17	18		729
1975				229	288	2	46	22		4				2	4	58	23	0		678

Table 3a. (Cont.)

Female

Year	1E	2C	2R	5	6W	6E	7CS	7CN	7W	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1976				445	174		46	29							11	113			1	819
1977				269	303		28	14							2	43				659
1978				207	356		85	22								48				718
1979				130	264		38	28							7	64				531
1980				272	109		70	12							5	82				550
1981		0		188	192		68	11	0						2	63				524
1982				236	219	2	58	28	0						6	56				605
1983				98	138	4	69	30							5	42				386
1984				87	114		38	55								76				370
1985			0	26	35	4	20	41							5	66				197
1986				0	15	2	35	43	2							54				151
1987							43	30								49				122
1988																				0
1989																				0
1990																				0
1991																				0
1992																				0
1993																				0
1994												3								3
1995												9								9
1996								2	1		0					11				14
1997									0	0	1	12								13
1998									3	4	4									11
1999							0	7	0							22				29
2000							1	4				0								5
2001							0	0	3	0	1	3								7
2002								31	0		0	2								33
2003							30		1	0	3	2								36
2004								14				8						0		22
2005							37	19	0		7	3								66
2006							35	12	1	1	2	1								52
2007							46	21	0		0	1								68
2008							38	18			0	6								62
2009							35	24	0	0	5	1								65
2010							28	20				2								50
2011							6	37				1								44
2012							38	30	1		0									69
2013							17	17				0								34
2014							14	16												30
2015							9	16												25
2016							9	13												22
2017							0	13	0	1	0	6				38				58
2018							23	8	0	0	1	8				31				71
2019							20	10	0							27				57
2020							5	25								2				32

Table 3b. The high catch series by sub-area and sex. The number of catch animals were set in line with the procedure of IWC (2021).

Male:

Year	7CS		7CN		11	
	High	Best	**High**	Best	**High**	Best
1930	**14**	7	**0**	0	**2**	1
1931	**14**	7	**2**	1	**0**	0
1932	**26**	13	**2**	1	**0**	0
1933	**26**	13	**2**	1	**0**	0
1934	**40**	20	**2**	1	**0**	0
1935	**40**	20	**2**	1	**2**	1
1936	**30**	15	**0**	0	**0**	0
1937	**74**	37	**0**	0	**2**	1
1938	**88**	44	**0**	0	**2**	1
1939	**88**	44	**2**	1	**0**	0
1940	**104**	52	**0**	0	**2**	1
1941	**74**	37	**2**	1	**0**	0
1942	**88**	44	**0**	0	**2**	1
1943	**134**	67	**2**	1	**0**	0
1944	**104**	52	**0**	0	**2**	1
1945	**88**	44	**0**	0	**0**	0

Female:

Year	7CS		7CN		11	
	High	Best	**High**	Best	**High**	Best
1930	**8**	4	**0**	0	**2**	1
1931	**8**	4	**0**	0	**4**	2
1932	**14**	7	**0**	0	**2**	1
1933	**14**	7	**2**	1	**2**	1
1934	**20**	10	**0**	0	**2**	1
1935	**20**	10	**0**	0	**2**	1
1936	**14**	7	**0**	0	**4**	2
1937	**36**	18	**2**	1	**2**	1
1938	**44**	22	**0**	0	**2**	1
1939	**44**	22	**0**	0	**4**	2
1940	**50**	25	**0**	0	**2**	1
1941	**36**	18	**0**	0	**4**	2
1942	**44**	22	**0**	0	**2**	1
1943	**64**	32	**0**	0	**4**	2
1944	**50**	25	**0**	0	**2**	1
1945	**44**	22	**2**	1	**4**	2

Table 3b. (Cont.)

Male:

Year	5		6W	
	High	Best	**High**	Best
1946	11	11	21	21
1947	**55**	19	**70**	21
1948	**55**	22	**70**	26
1949	**55**	25	**70**	31
1950	**55**	29	**70**	37
1951	**55**	31	**70**	40
1952	**55**	36	**70**	45
1953	**55**	42	**70**	50
1954	**55**	43	**70**	54
1955	**56**	49	**70**	60
1956	**57**	54	**70**	62
1957	59	59	70	70

Female:

Year	5		6W	
	High	Best	**High**	Best
1946	10	10	18	18
1947	**56**	18	**68**	19
1948	**56**	21	**68**	25
1949	**56**	25	**68**	31
1950	**56**	29	**68**	34
1951	**56**	33	**68**	42
1952	**56**	37	**68**	45
1953	**56**	39	**68**	49
1954	**56**	45	**68**	55
1955	**66**	58	**68**	59
1956	**66**	62	**68**	66
1957	79	79	68	68

3.2. Incidental catches (bycatches and other removal)

Table 4 shows the number of incidental catches of minke whales by year and sub-area. The table was updated through communication with IWC SC Secretariat. Japan has reported the number of bycatches in sub-areas 1E, 2C, 6E, 7CS, 7CN since 2001. Korea has reported the number of bycatches in sub-areas 1, 5 and 6W since 1996 to 2019.

Table 4. Bycatches by year and sub-area.

Year	1E	2C	5	6W	6E	7CS	7CN	10E	11
1996	0	0	0	128	0	0	0	0	0
1997	0	0	0	78	0	0	0	0	0
1998	0	0	0	47	0	0	0	0	0
1999	0	0	0	54	0	0	0	0	0
2000	0	0	12	80	0	0	0	0	0
2001	1	10	9	141	25	8	3	4	3
2002	7	19	8	75	45	17	13	3	5
2003	5	17	10	75	61	18	15	0	8
2004	4	19	9	52	66	14	9	0	3
2005	4	33	7	98	55	17	10	3	6
2006	3	28	11	67	76	21	16	0	3
2007	7	42	12	59	69	20	11	0	6
2008	9	23	12	61	68	17	11	2	3
2009	3	17	10	70	69	25	3	0	1
2010	3	18	8	63	74	17	8	0	4
2011	6	28	15	70	65	8	9	0	1
2012	5	25	8	66	56	15	9	0	4
2013	5	20	8	43	54	15	9	2	0
2014	3	21	7	43	74	23	16	1	2
2015	5	28	7	78	84	26	12	0	1
2016	7	34	10	84	86	22	17	3	0
2017	5	32	12	57	80	34	10	1	2
2018	2	18	7	73	40	18	9	0	0
2019	3	15	3	55	54	23	9	0	0
2020	2	10	0	0	34	16	9	0	0

The historical bycatch in sub-area *k* in year *t* is given by:

$$C_{B,t}^{k} = A^{k} P_{t}^{k} E_{t}^{k}$$

where A^k is the bycatch constant, E_t^k is the number of nets in sub-area *k* in year *t* and P_t^k is the total population size (including calves) in sub-area *k* in year *t* averaged over all eight time periods. The values of the bycatch constants are set by fitting during the conditioning process. The numbers of set-nets by type, year and area are listed in below section. Also, further details are given in Annex H of IWC (2012).

3.3. Set nets

Information on the number of set net by year and sub-area are shown for Japan and Korea in Table 5a and

6a, respectively. Same as the case of direct catch series, the 'high' effort series was used as a sensitivity trial (Trial 02) in order to examine the implications of uncertainty about historical catches. Tables 5b and 6b show the 'high' set net numbers where they differ from the 'best' effort series. See further details in the section below.

Japanese net

Table 5a lists the number of large-scale set nets by year and sub-area in Japan. The number of large-scale nets for the period 1979-2018 were revised based on the information of number by month and prefecture which derived from the coastguard of Japan. The number of nets in 2019-2020 are the same as in 2018. Although there are three type of nets used in *IST* until 2014 (IWC, 2014), only large-scale type nets information is available since 2006. In any case, the number of minke bycatches in salmon nets is small in comparison with the number of large-scale nets. Hence, we assumed only the number of large-scale set nets in the present *IST*, in line with the assumption in IWC SC68c.

Korean net and set net fishery license

Table 6a lists the number of large-scale set nets and set net fishery license by year and sub-area in Korea. These data have two sources: i) the number of Korean set nets (estimated by linear interpolation assuming 0 in 1946 for the period 1946-1989, and reported by a Korean scientist for the period 1990-1993, and ii) the number of set net fishery license obtained through communication with IWC SC secretariat (1994-2019). The number of license in 2020 is the same as in 2019.

In previous *ISTs* (IWC, 2014; JRT, 2019), the number of set nets reported between 1990 and 2009 were used. The number of set nets in Korea was not available since 2010. Then the number of set nets in the period 2010-2018 was set the same as in in 2009. For the purpose of the current *ISTs*, the number of set net fishery license was used instead of the number of set net. The number of fishery license is expected to be available in the future.

High series

Table 5b shows the 'high' effort series for Japanese large-scale set net. The number of nets are identical to the 'best' series except for the some sub-areas and years. The values in the 'high' series between 1946 and1969 are doubled regarding the ‘best’ values or set up to be equal the number of nets in 1969.

Table 6b shows the 'high' effort series for Korean set net in sub-areas 5 and 6W. The values in the 'high' series between 1957 and 1969 are doubled regarding the ‘best’ values or set up to be equal the number of nets in 1969.

Table 5a. The number of large-scale set nets by sub-area and year.

Japan:

Year	1E	2C	6E	7CS	7CN	10E	11	Note
1946	24	67	103	41	7	9	2	
1947	26	73	112	44	7	10	2	
1948	29	79	122	48	8	11	2	
1949	31	85	131	52	8	12	2	
1950	33	91	141	55	9	12	2	
1951	35	97	150	59	10	13	2	
1952	37	103	159	63	10	14	2	
1953	40	109	169	66	11	15	3	
1954	42	115	178	70	11	16	3	
1955	44	121	187	74	12	17	3	
1956	46	127	197	77	13	17	3	
1957	48	133	206	81	13	18	3	
1958	51	139	216	85	14	19	3	
1959	53	145	225	88	14	20	3	
1960	55	151	234	92	15	21	4	
1961	57	157	244	96	16	22	4	
1962	59	164	253	100	16	22	4	IWC (2014)
1963	62	170	262	103	17	23	4	
1964	64	176	272	107	17	24	4	
1965	66	182	281	111	18	25	4	
1966	68	188	291	114	19	26	4	
1967	70	194	300	118	19	27	5	
1968	73	200	309	122	20	27	5	
1969	75	206	319	125	20	28	5	
1970	77	212	328	129	21	29	5	
1971	80	209	324	127	21	29	5	
1972	83	206	321	124	21	29	5	
1973	86	203	317	122	20	28	5	
1974	89	200	314	119	20	28	5	
1975	92	197	310	117	20	28	5	
1976	82	197	320	119	20	33	4	
1977	72	197	330	122	20	39	3	
1978	61	197	339	124	20	44	1	
1979	45	201	355	120	29	24	11	
1980	48	204	365	128	28	23	11	
1981	50	201	367	131	26	20	9	
1982	48	198	381	129	26	21	10	
1983	53	195	384	130	36	30	14	
1984	50	189	387	139	48	41	19	
1985	46	189	412	139	42	35	16	
1986	49	196	408	134	49	42	19	
1987	47	194	405	137	48	41	19	
1988	46	187	400	130	39	33	15	
1989	55	181	391	139	34	29	13	
1990	55	178	404	133	35	29	13	
1991	60	174	401	132	28	23	11	
1992	55	166	392	132	26	22	10	
1993	61	179	397	132	27	21	10	
1994	54	175	378	128	28	22	10	
1995	55	175	372	116	26	20	9	
1996	56	171	371	129	26	20	9	
1997	53	168	368	130	24	19	9	
1998	55	164	370	130	26	19	9	No. net revised in 2021
1999	54	166	363	128	28	21	10	
2000	54	165	360	128	27	21	10	
2001	56	149	354	128	28	22	10	
2002	51	161	363	129	32	26	12	
2003	48	163	360	136	31	25	11	
2004	50	159	348	135	26	21	10	
2005	52	158	326	131	25	20	9	
2006	45	154	310	130	26	21	10	
2007	39	132	298	112	7	4	2	
2008	39	124	301	115	21	16	7	
2009	41	127	303	118	21	15	7	
2010	39	127	306	113	20	14	7	
2011	39	126	302	91	20	14	7	
2012	38	125	305	93	20	14	6	
2013	37	117	300	90	20	14	6	
2014	35	117	293	95	19	14	7	
2015	35	112	293	98	19	14	7	
2016	35	112	261	95	19	14	7	
2017	33	110	249	84	19	14	6	
2018	30	100	254	77	19	14	6	
2019	30	100	254	77	19	14	6	replicate 2018
2020	30	100	254	77	19	14	6	

Table 6a. The number of Korean set nets and set net fishery license by sub-area and year.

Korea:

Year	1E	2C	5	6W	6E	7CS	7CN	10E	11	Note
1946	0	0	0	0	0	0	0	0	0	IWC (2014)
1947	0	0	2	5	0	0	0	0	0	
1948	0	0	4	11	0	0	0	0	0	
1949	0	0	6	16	0	0	0	0	0	
1950	0	0	8	21	0	0	0	0	0	
1951	0	0	10	27	0	0	0	0	0	
1952	0	0	12	32	0	0	0	0	0	
1953	0	0	14	38	0	0	0	0	0	
1954	0	0	15	43	0	0	0	0	0	
1955	0	0	17	48	0	0	0	0	0	
1956	0	0	19	54	0	0	0	0	0	
1957	0	0	21	59	0	0	0	0	0	
1958	0	0	23	64	0	0	0	0	0	
1959	0	0	25	70	0	0	0	0	0	
1960	0	0	27	75	0	0	0	0	0	
1961	0	0	29	80	0	0	0	0	0	
1962	0	0	31	86	0	0	0	0	0	
1963	0	0	33	91	0	0	0	0	0	
1964	0	0	35	97	0	0	0	0	0	
1965	0	0	37	102	0	0	0	0	0	
1966	0	0	39	107	0	0	0	0	0	
1967	0	0	41	113	0	0	0	0	0	
1968	0	0	43	118	0	0	0	0	0	
1969	0	0	44	123	0	0	0	0	0	
1970	0	0	46	129	0	0	0	0	0	
1971	0	0	48	134	0	0	0	0	0	
1972	0	0	50	139	0	0	0	0	0	
1973	0	0	52	145	0	0	0	0	0	
1974	0	0	54	150	0	0	0	0	0	
1975	0	0	56	156	0	0	0	0	0	
1976	0	0	58	161	0	0	0	0	0	
1977	0	0	60	166	0	0	0	0	0	
1978	0	0	62	172	0	0	0	0	0	
1979	0	0	64	177	0	0	0	0	0	
1980	0	0	66	182	0	0	0	0	0	
1981	0	0	68	188	0	0	0	0	0	
1982	0	0	70	193	0	0	0	0	0	
1983	0	0	71	198	0	0	0	0	0	
1984	0	0	73	204	0	0	0	0	0	
1985	0	0	75	209	0	0	0	0	0	
1986	0	0	77	215	0	0	0	0	0	
1987	0	0	79	220	0	0	0	0	0	
1988	0	0	81	225	0	0	0	0	0	
1989	0	0	83	231	0	0	0	0	0	
1990	0	0	85	236	0	0	0	0	0	
1991	0	0	85	286	0	0	0	0	0	
1992	0	0	96	305	0	0	0	0	0	
1993	0	0	96	291	0	0	0	0	0	
1994	0	0	168	464	0	0	0	0	0	Source: Statistics System of Ministry of Oceans and Fisheries, Republic of Korea, http://www.mof.go.kr/statPortal/
1995	0	0	159	447	0	0	0	0	0	
1996	0	0	149	443	0	0	0	0	0	
1997	0	0	144	438	0	0	0	0	0	
1998	0	0	142	433	0	0	0	0	0	
1999	0	0	138	427	0	0	0	0	0	
2000	0	0	129	426	0	0	0	0	0	
2001	0	0	128	425	0	0	0	0	0	
2002	0	0	135	417	0	0	0	0	0	
2003	0	0	134	422	0	0	0	0	0	
2004	0	0	133	421	0	0	0	0	0	
2005	0	0	132	421	0	0	0	0	0	
2006	0	0	131	420	0	0	0	0	0	
2007	0	0	141	414	0	0	0	0	0	
2008	0	0	126	414	0	0	0	0	0	
2009	0	0	125	411	0	0	0	0	0	
2010	0	0	125	411	0	0	0	0	0	
2011	0	0	121	405	0	0	0	0	0	
2012	0	0	121	399	0	0	0	0	0	
2013	0	0	115	398	0	0	0	0	0	
2014	0	0	115	393	0	0	0	0	0	
2015	0	0	117	385	0	0	0	0	0	
2016	0	0	115	381	0	0	0	0	0	
2017	0	0	114	380	0	0	0	0	0	
2018	0	0	114	379	0	0	0	0	0	
2019	0	0	114	374	0	0	0	0	0	
2020	0	0	114	374	0	0	0	0	0	replicate 2019

Table 5b. The high effort series for Japanese large-scale set net by sub-area and year. The number of nets was set in line with the procedure of IWC (2014; 2021).

Japanese large-scale set net:

Year	1E		2C		6E		7CS		7CN		10E		11	
	High	Best	**High**	Best	**High**	Best	**High**	Best	**High**	Best	**High**	Best	**High**	Best
1946	**48**	24	**134**	67	**206**	103	**82**	41	**14**	7	**18**	9	**4**	2
1947	**52**	26	**146**	73	**224**	112	**88**	44	**14**	7	**20**	10	**4**	2
1948	**58**	29	**158**	79	**244**	122	**96**	48	**16**	8	**22**	11	**4**	2
1949	**62**	31	**170**	85	**262**	131	**104**	52	**16**	8	**24**	12	**4**	2
1950	**66**	33	**182**	91	**282**	141	**110**	55	**18**	9	**24**	12	**4**	2
1951	**70**	35	**194**	97	**300**	150	**118**	59	**20**	10	**26**	13	**4**	2
1952	**74**	37	**206**	103	**318**	159	**125**	63	**20**	10	**28**	14	**4**	2
1953	**75**	40	**206**	109	**319**	169	**125**	66	**20**	11	**28**	15	**5**	3
1954	**75**	42	**206**	115	**319**	178	**125**	70	**20**	11	**28**	16	**5**	3
1955	**75**	44	**206**	121	**319**	187	**125**	74	**20**	12	**28**	17	**5**	3
1956	**75**	46	**206**	127	**319**	197	**125**	77	**20**	13	**28**	17	**5**	3
1957	**75**	48	**206**	133	**319**	206	**125**	81	**20**	13	**28**	18	**5**	3
1958	**75**	51	**206**	139	**319**	216	**125**	85	**20**	14	**28**	19	**5**	3
1959	**75**	53	**206**	145	**319**	225	**125**	88	**20**	14	**28**	20	**5**	3
1960	**75**	55	**206**	151	**319**	234	**125**	92	**20**	15	**28**	21	**5**	4
1961	**75**	57	**206**	157	**319**	244	**125**	96	**20**	16	**28**	22	**5**	4
1962	**75**	59	**206**	164	**319**	253	**125**	100	**20**	16	**28**	22	**5**	4
1963	**75**	62	**206**	170	**319**	262	**125**	103	**20**	17	**28**	23	**5**	4
1964	**75**	64	**206**	176	**319**	272	**125**	107	**20**	17	**28**	24	**5**	4
1965	**75**	66	**206**	182	**319**	281	**125**	111	**20**	18	**28**	25	**5**	4
1966	**75**	68	**206**	188	**319**	291	**125**	114	**20**	19	**28**	26	**5**	4
1967	**75**	70	**206**	194	**319**	300	**125**	118	**20**	19	**28**	27	**5**	5
1968	**75**	73	**206**	200	**319**	309	**125**	122	**20**	20	**28**	27	**5**	5
1969	**75**	75	**206**	206	**319**	319	**125**	125	**20**	20	**28**	28	**5**	5

Table 6b. The high effort series for Korean set net by sub-area and year. The number of net were set in line with the procedure of IWC (2014; 2021).

Korean set net and set net fishery license:

Year	5		6W	
	High	Best	**High**	Best
1957	**42**	21	**118**	59
1958	**44**	23	**123**	64
1959	**44**	25	**123**	70
1960	**44**	27	**123**	75
1961	**44**	29	**123**	80
1962	**44**	31	**123**	86
1963	**44**	33	**123**	91
1964	**44**	35	**123**	97
1965	**44**	37	**123**	102
1966	**44**	39	**123**	107
1967	**44**	41	**123**	113
1968	**44**	43	**123**	118
1969	**44**	44	**123**	123

4. Future commercial and incidental catches

Future (t > 2021) commercial catches and bycatch area allocated to sex, sub-area, month and year based on the information indicated below (Table 7a, 7b, 8a, 8b).

Allocation for commercial catches:
Table 7a shows the summary of the western North Pacific mike whale direct catch series (1930-2020) by sub-area, sex and month. However, future commercial catches in sub-areas 7CS and 7CN were allocated following the patterns Table 7b since the genetic data show differences between in-shore and off-shore catches. It was assumed that future catches will be taken off-shore (>10 n.mile), and were allocated to stock based on the mixing proportions set using genetic data from samples collected by scientific permit survey from 1996-2019 and commercial whaling from 2019-2020 (Table 7b).

Table 7a. Summary of the final western North Pacific mike whale direct catch series (1930-2020) by sub-area, sex and month.

Sub-area	Male								Female								Total	Male	Female
	Jan-Mar	Apr	May	Jun	Jul	Aug	Sep	Oct-Dec	Jan-Mar	Apr	May	Jun	Jul	Aug	Sep	Oct-Dec			
1E	17	0	0	0	1	0	0	0	11	0	0	0	0	0	0	0	29	18	11
2C	3	2	2	3	2	0	1	0	2	2	0	0	1	0	0	0	18	13	5
2R	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	4	2	2
5	981	1280	906	671	568	322	102	174	1128	1457	1244	757	570	300	121	185	10766	5004	5762
6W	181	383	1325	1167	392	202	557	1063	178	364	1300	1136	376	189	545	1009	10367	5270	5097
6E	181	223	135	13	21	0	8	2	95	144	95	16	3	0	6	1	943	583	360
7CS	210	1011	1826	768	129	8	1	0	164	1134	1371	464	27	1	0	0	7114	3953	3161
7CN	0	0	77	241	387	426	940	199	0	20	89	101	163	122	312	113	3190	2270	920
7WR	0	1	49	33	3	1	10	0	0	0	9	3	3	0	0	0	112	97	15
7E	0	0	37	21	3	0	13	1	0	0	7	2	0	0	9	0	93	75	18
8	0	0	39	101	99	21	11	6	0	0	8	10	17	4	5	6	327	277	50
9	0	0	32	82	183	218	17	0	0	0	9	11	16	29	3	0	600	532	68
9N	0	0	1	2	5	8	0	1	0	0	0	6	0	11	0	0	34	17	17
10W	0	0	6	12	1	0	2	0	0	2	0	9	0	0	0	0	32	21	11
10E	2	25	42	119	83	26	5	3	0	1	28	60	26	9	7	0	436	305	131
11	0	62	248	503	560	230	143	29	2	465	872	909	607	273	113	25	5041	1775	3266
12SW	0	0	0	1	11	9	1	0	0	0	1	5	16	27	5	0	76	22	54
12NE	0	0	0	0	36	9	10	0	0	0	0	3	33	14	6	0	111	55	56
13	0	0	0	0	0	2	0	0	0	0	0	0	1	3	0	0	6	2	4
Total	1576	2988	4725	3737	2484	1482	1821	1478	1581	3589	5033	3492	1859	982	1133	1339	39299	20291	19008

Table 7b. Time invariant fixed proportions by stock to be used in removing future commercial catches from the off shore area (> 10 n.mile) in sub-areas 7CS and 7CN.

Sub-area	Months	Sample size		J:Total
		J-stock	O-stock	
7CS	Apr	36	124	0.225
7CS	May	57	205	0.218
7CS	Jun-Sep	6	70	0.079
7CN	Apr-Jun	18	151	0.107
7CN	Jul-Dec	143	619	0.188

Allocation for incidental catches:
Table 8a shows the proportion of bycatch by sex, month and sub-area used for allocation purpose (Table 8a). The values were set using all available bycatches known by sub-area, sex and month, up to and including 2020 (Japan) and 2019 (Korea). As well as the case of commercial catches, in sub-areas 7CS and 7CN, where the genetic data show differences between on-shore and offshore catches, bycatches are taken on shore and split to stock using mixing proportions calculated from the number of sampled whales that were assigned to each stock using genetic data from by catches only, following Table 8b.

Table 8a. The percentage of the incidental catch in sub-area *k* that is taken by sex and month.

Sub-area	Male								Female								Sample size
	Jan-Mar	Apr	May	Jun	Jul	Aug	Sep	Oct-Dec	Jan-Mar	Apr	May	Jun	Jul	Aug	Sep	Oct-Dec	
1E	18.2	8.0	2.3	9.1	1.1	0.0	0.0	3.4	21.6	5.7	10.2	8.0	5.7	2.3	0.0	4.5	88
2C	15.9	4.3	2.9	0.7	0.9	0.4	0.0	14.3	25.5	2.5	3.1	2.5	2.2	1.6	0.2	23.0	447
5	5.2	3.4	10.3	19.8	1.7	2.6	1.7	12.1	9.5	4.3	7.8	7.8	3.4	0.0	1.7	8.6	116
6W	13.3	5.9	6.6	4.8	2.7	3.0	4.2	14.6	13.2	5.0	4.6	6.1	1.2	1.5	1.7	11.6	863
6E	16.2	9.2	6.0	2.1	2.4	2.1	1.1	8.9	17.4	9.3	6.7	3.1	1.8	1.8	0.9	11.0	1210
7CS	10.5	4.3	10.0	5.9	2.2	0.8	0.3	11.1	11.9	8.1	9.2	7.8	2.2	1.4	0.8	13.5	370
7CN	3.4	3.9	3.4	8.3	6.9	2.5	1.0	12.3	3.4	8.3	11.3	10.8	5.4	2.9	1.5	14.7	204
10E	0.0	0.0	0.0	0.0	0.0	5.3	0.0	52.6	0.0	0.0	0.0	5.3	0.0	5.3	0.0	31.6	19
11	0.0	0.0	0.0	3.9	0.0	0.0	5.9	23.5	0.0	0.0	17.6	19.6	3.9	0.0	3.9	21.6	51

Table 8b. Time invariant fixed proportions by stock to be used in removing bycatch from sub-areas 7CS and 7CN.

Sub-area	Months	Sample size		J:Total
		J-stock	O-stock	
7CS	Jan.-Apr.	78	39	0.667
7CS	May	20	42	0.323
7CS	Jun.-Dec.	112	41	0.732
7CN	Jan.-Jun.	46	53	0.465
7CN	Jul.-Dec.	71	15	0.826

REFERENCES

International Whaling Commission. 2012. Report of the first RMP intersessional workshop for western North Pacific common minke whales. *J. Cetacean Res. Manage*. 13 (*suppl.*): 411-460.

International Whaling Commission. 2014. Report of the Scientific Committee, Annex D1. Report of the Working Group on the Implementation Review for Western North Pacific Common Minke Whales. Appendix 2. North Pacific minke whale Implementation Simulation Trial Specifications. Adjunct 2. Mixing matrices. *J. Cetacean Res. Manage*. 15 (*suppl.*):112-188.

International Whaling Commission. 2021. Report of the Scientific Committee, Annex D. Revised Specifications for Western North Pacific Minke Whales. *J. Cetacean Res. Manage*. (in press).

Japan's RMP Team. 2019. Catch limits for western North Pacific sei, Bryde's and common minke whales calculated in line with the IWC's Revised Management Procedure (RMP). https://www.jfa.maff.go.jp/e/whale/attach/pdf/index-14.pdf

Ohsumi, S. 1982 Minke whales in the coastal waters of Japan, 1980 and a population assessment of the Okhotsk Sea-West Pacific stock. *Rep. Int. Whal. Commn* 32:283-6 [SC/33/Mi8].